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ABSTRACT

As part of a continuing series of research studies on stress in schools, this study examined the construct validity of peripheral temperature at the fingertips as a measure of school stress. Measurements were made in classes selected at random from 11 volunteer schools in South Carolina. Three types of correlational studies were undertaken: (1) peripheral temperature was residualized for extraneous variation associated with both ambient temperature and time of day, conceptualized as a point on the circadian thermal cycle; (2) the corrected peripheral temperature was tested in hypotheses on groups which were presumed to vary in average school stress; and (3) common variables used in describing schools were correlated with corrected peripheral temperature to identify those variables that were associated with school stress. A strong school effect was found in the variation in corrected peripheral temperature, and it was shown to increase as student experience in the school grew. Certain curricula, noted for their difficulty, were found to influence peripheral temperature in directions suggestive of increasing stress on the learner. While this research cannot assert the validity of corrected peripheral temperature as a measure of stress, it contributes some evidence in support of construct validity. Sixty tables and seven pages of references are provided; the appendixes consist of forms used in the study, including the field tested student attitude inventory. (NB)

CORRELATES OF SCHOOL STRESS

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The principal investigator acknowledges with grateful appreciation the assistance of all those persons involved in planning, implementing, and writing the final report of this research study. Because the investigation required the management of a great body of data on which sophisticated statistical operations were necessary and because the analysis competed with several additional studies within the wide area of the research for the attention of the staff, publication of this report is finally realized three years after implementation of the initial observations.

Any acknowledgment must place in a very prominent position the eleven schools which agreed to assist this study by becoming its laboratories. One of the conditions under which schools agreed to participate, however, was the guarantee of anonymity. Consequently, to those eleven necessarily unnamed schools, the principal investigator gratefully and sincerely acknowledges their essential assistance.

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Both of these assistants kept positive attitudes about the amount of work and the long hours.

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ABSTRACT

As part of a continuing series of research studies on stress in schools, the researcher studied the construct validity of peripheral temperature at the fingertips as a measure of school stress. Upon measurements made in classes selected at random from 11 volunteer schools in the central part of South Carolina, three types of correlational studies were undertaken. First, following previous research, peripheral temperature was residualized for extraneous variation associated with both ambient temperature and the time of day, conceptualized as a point on the circadian thermal cycle. Second, the corrected peripheral temperature was tested in hypotheses on groups which were presumed to vary in average school stress. The performance of the measure was mixed, perhaps because of any of three reasons: (1) possible residual contamination even after known sources of contamination were removed from peripheral temperature; (2) ambiguous hypotheses based upon somewhat questionable presumptions regarding differential stress distribution in groups; and (3) relatively unreliable measures of some key variables intended for use as independent variables in construct validation hypotheses. Third, common variables used in describing schools were correlated with corrected peripheral temperature to identify those variables that were associated with school stress. The mixed performance of the stress measure in the second component of the study tended logically to reduce this third

component to a study of correlates of corrected peripheral temperature, a far less salient issue.

A strong school effect was discovered in the variation in corrected peripheral temperature, and it was shown to increase as student experience in the school grew. Certain curricula, noted for their difficulty, were found to influence peripheral temperature in directions suggestive of increasing stress on the learner. Black students were shown to vary in peripheral temperature as one would expect of a measure of stress as they found themselves in schools with varying proportions of white students. However, previous research which showed relevant categories, that is, females and blacks, to exhibit greater stress was supported very weakly by corrected peripheral temperature. Its concurrent validity with a common pencil-and-paper anxiety scale was unimpressive.

While this research cannot assert the validity of corrected peripheral temperature as a measure of stress, it contributes some evidence in support of construct validity. Subsequent research will be required to resolve the issue firmly.

INTRODUCTION

Within the interplay of stimulus and response, stress is the set of responses at the lowest level of predictable success. Humans interact with stimuli from the environment by responding to it. For those stimuli which provoke a response from the autonomic nervous system, a very small set of responses is observable. For example, finding the hand on a very hot object results in the quick removal of the hand from the object. For most stimuli, however, a wide range of responses is possible. The responses to unfaithfulness of a loved one, for example, are so varied that novels continue to sample the reactions, with no exhaustion of the possibilities in sight. Clearly, not all of the possible responses are equivalent; some have a greater possibility of assisting in the achievement of goals than others. Usually, in a healthy person, the responses which promote the goals of a person are likeliest to be observed. When no response predictive of success is available, the individual enlists one or more of the stress reactions. These responses are "damage-control" options which make up what Hans Selye (1976) called the "fight or flight reaction." These reactions tend to allocate the resources of the body to guard against widely generalized possible threats. The simultaneous use of many resources debilitates and drains the reserves of the body.

Generally, when a predictably successful response lies at hand, minimal stress develops. The stress responses appear only when predictable success is low; thus, stress is the body of generalized responses of the organism which becomes effective when specific responses are unavailable. Stress behaviors may be used as insurance in concert with specific responses. Therefore, when fighting a fire, seasoned firefighters use their skills; but their bodies prepare to flee, just in case the fire overcomes their protective science.

Anxiety is a mental state which is closely associated with stress because stress almost always accompanies anxiety. Anxiety is the mental state associated with a relatively high prediction of behavioral failure. The anxiety can be situation specific, as when the frail youth stands up to the school bully, or it may be generalized. Because anxiety develops when no predictably successful behaviors can be found or where the behavior of an individual is likely to fail, the only set of behaviors which can be confidently expected to appear are the stress behaviors: the "damage-control" behaviors, the "fight or flight" behaviors, or the generalized behaviors which cover as many possibilities of responses to threat as possible, even straining the resources of the system in the wide allocation of attention and energy.

From the psychological perspective, subjectivists prefer to think of "anxiety." Behaviorists and objectivists, however, prefer to speak of "stress."

Authorities (Archer, 1982; Blom, Cheney & Snoddy, 1986; Rice, 1987; Sehnert, 1981; Selye, 1976) recognize stress as motivating (eustress) and incapacitating (distress), making the phenomenon difficult to understand. Hans Selye (1974, 1976) thought that each person has an optimum level of stress, below and above which is detrimental.

In spite of the volume of books on the subject of stress, very little is known about stress and school. Because school represents the environment for young people for many of their waking hours during the day, an understanding of the phenomenon of stress and its relationship to the school climate is of interest to educators as they strive to provide better learning conditions for students. In hope of assisting educators, the researcher in this study investigated the relationship between peripheral temperature, a measure showing a physical change in response to stressors, and a number of other aspects: state anxiety; curriculum; ability level of students; school differences; rating by teachers; grade level; student size, sex, and race; teacher expectations; attitudes of students about school and vocational plans; and other school variables, such as dropout rate, expulsion rate, suspension rate, retention rate, poverty level, proportion of students qualifying for free lunch, proportion of single-parent families, and average achievement level.

Peripheral temperature is an excellent candidate for a physiological measure of stress. Skin temperature is dependent on the flow of blood through the arteries and arterioles (King & Montgomery, 1980). Because blood circulation is controlled by the sympathetic nervous system, changes in sympathetic activity produce changes in skin temperature. When a person relaxes, the blood flows more easily out from the heart and lungs to the extremities, thus increasing the temperature at the extremities. When a person is anxious, the arterioles, which mediate the flow of blood from arteries to veins, and some veins constrict to reduce the flow of blood toward the periphery of the body, thus reducing blood circulation in the skin and lowering peripheral skin temperature.

Within the common experience of educators is the knowledge that different schools, even within the same geographical region, differ in terms of the demands which they impose on students. Assuming that schools were selected for study in order to assure a wide variance in their imposition of demands, a researcher would expect to observe a greater variability in peripheral temperature among schools than anticipated from sampling error where the only source of variability is that within schools. An investigator would expect similar results on a valid measure of anxiety because a more demanding school should produce more anxious students who give evidence of increased stress while at school. Scores on an anxiety scale (where the score increases consonant with increases in anxiety) should correlate negatively with peripheral temperature, which seems to decrease with increasing anxiety.

Related Literature

Stress manifests itself in a number of different ways depending on the individual personality and the particular situation. Numerous factors tend to cause stress or anxiety in school children. Many of these factors relate directly to the school or classroom.

Spielberger (1972) defined state anxiety as the anxiety a person experiences when exposed to a specific situation or condition which the individual perceives to be stressful or threatening. Considering the length of time that children spend in the school setting, it seems likely that much of the stress and anxiety experienced by students is directly related to some school situation or factor. Dunn (1968) listed five types of anxiety which were relative to the school setting: report card, failure (retention), achievement, test, and recitation. Phillips (1978) divided the concept of school anxiety into two categories: achievement anxiety and social anxiety. Gage and Berliner (1978) reported that examination announcements and administrations often caused test anxiety. Other researchers revealed the fact that the failure syndrome appeared to be a major stress factor during childhood (Yamamoto, 1979) and adolescence (Friesen, 1985; Purkerson & Whitfield, 1982). According to Garbowsky (1984), pressure to achieve high grades was one of the greatest sources of stress for junior high and senior high students, particularly gifted students who had high expectations for themselves. Several researchers reported that reading anxiety (Forman & O'Malley, 1984; Powers, Hart & Danathan, 1981) and mathematics anxiety (Dew, Galassi & Galassi, 1984; Forman & O'Malley, 1984) were two types of achievement anxiety which had adverse effects on academic performance. Recitation anxiety manifested itself in the form of avoiding reading orally and, when reciting, stammering or having a quivering voice (Forman & O'Malley, 1984). Edmister and Lewis (1983) reported such factors as the influence of authority figures or older children and the school environment as possible causes of anxiety. To Edmister and Lewis, the environment referred to a psychological rather than physical environment and included seemingly trivial events, such as getting lost inside the building; not being able to find specific areas (cafeteria or bathroom); or not being able to perform certain acts (unlocking a locker). Interpersonal (social) anxiety emerged as a major factor affecting the anxiety and performance of students (Felsen, 1973; Felsen & Blumberg, 1973; Phillips, 1978; Warren, Smith & Velten, 1984). Students in English (Felsen & Blumberg, 1973), physics, and chemistry (Felsen, 1973) classes who had high classroom peer attraction and viewed themselves as psychological members of the classroom peer group had more positive attitudes toward school, less classroom-related anxiety, and more positive self-concepts than students who had low peer attraction. In a study of school anxiety among fourth, fifth, and sixth graders, Yamamoto and Byrnes (1984) recognized that children having low classroom social status were more concerned about school-related experiences than popular children; however, the popular children were more personally insecure.

Attitudes of teachers and teaching styles affect students psychologically, thus producing stress. Gregorc (1979) stated that teaching styles seemed to cause some degree of student anxiety because the teacher seldom geared instruction to compensate for individual differences in learning styles. According to Saigh (1984-1985), unscheduled quizzes increased student anxiety and course dissatisfaction. In a study of sixth grade students, frequent testing produced more stress than less frequent testing (Proger, Mann, Taylor & Morrell, 1969). Verbal communication problems, such as a teacher using ego-involving instructions (Denny, 1966; Rodgers, 1979/1980; Spielberger & Smith, 1966) or talking too fast, as well as teacher expectations (Phillips, 1978), proved to be sources of stress in the classroom. Teacher behavior which was classified as rewarding or reinforcing tended to facilitate student achievement and attitudinal development (Flanders, 1964; Hough, 1967; Zimmerman, 1970), whereas punishing behavior inhibited increased student anxiety (Zimmerman, 1970). Coates and Thoresen (1976) found that teacher stress adversely affected student-teacher relationships, student adjustment, and student achievement. Knight (1985) discussed the effect of teacher countenance, tone of voice, gestures, and dress on the teacher-student relationship.

The school principal has an impact on stress levels in the school. Calabrese (1985) reported that principals who were involved with students positively influenced student morale, thus reducing discipline problems. Hopkins and Crain (1985) noted a decrease in failure and dropout rates and an increase of students taking foreign languages, mathematics, and science when the administration, staff, and students of a school worked together to create a positive school climate. Matthews and Brown (1976) stated that the attitude of a classroom teacher was reflective of the rapport between the teacher and the principal or school administration; thus, the principal affected indirectly the attitudes of students toward the school.

Evidence of the relationship of the solely physical environment to school anxiety was almost nonexistent. However, Foreman and O'Malley (1984) wrote that, depending on the type of physical environment to which students were accustomed, it was possible that factors, such as crowding, noise, temperature, lighting, and architectural structure, had an impact on the health and behavior of students and interacted with personal coping strategies in determining a stress reaction.

Curriculum structure and individual school practices tend to be sources of school anxiety. In one study of students who were ability grouped, students near the cutoff showed significant changes and differentiation in achievement test and self-esteem scores (Abadzi, 1984). It was possible that students in the high ability group functioning at the lower level of that group experienced frustration because these students were the lowest in the class. In contrast, the students in the upper part of the regular ability group displayed little frustration, probably because these students received reinforcement for being the best in the class. Guarino (1982/1983) reported that elementary children in nongraded schools had higher achievement, lower levels of anxiety, and higher levels of self-esteem than pupils in graded schools.

A number of researchers studied the relationship of school stress or anxiety to age, sex, race, and socioeconomic status. Dunn (1968) reported that anxiety decreased with age in relationship to tests, failure, and report cards; remained constant on achievement; and increased on recitation. In general, however, it appeared that the negative feeling for school increased as children grew older. In addition, Dunn found that girls had higher school anxiety, with the exception of report card anxiety, than did boys. In a study with junior high students, females exhibited higher anxiety levels for achievement, test, and recitation than did males (Morris, Finkelstein & Fisher, 1976). Rodgers (1979/1980) found that junior and senior high school females exhibited higher scores on both general anxiety and test anxiety than did males. After administering Sarason's <u>Test Anxiety Scale</u> to junior and senior high students, Rodgers (1979/1980) found that more black students scored at the medium and high anxiety levels than did white students. School anxiety appeared to be highest among lower class minority children (Dunn, 1968; Phillips, 1978), with socioeconomic background being a more influential factor than ethnicity (Phillips, 1978). Phillips stated that anxiety was highest among black students when students felt that they were being compared to other students in the class. Phillips found, also, that stress for black students was rooted in achievement aspirations and physical aggression, whereas social norms were the basis of stress for white students. Stress in upper lower class children tended to be related to deficiencies, particularly in relation to achievement demands and avoidance of failure. Edmister and Lewis (1983) reported that minority status per se caused anxiety, whether it was due to socioeconomic or ethnic status, a handicap, grade retention, or membership in remedial classes.

The concept of school anxiety or stress is complex because stress has physical, cognitive, and psychosocial aspects. Previous literature cited studies which used mainly self-report scales as their measures of anxiety or stress. The prospect of an inexpensive physiological measure of stress to replace existing instruments, notorious for their low reliability, argues forcefully for the present study.

Hypotheses

That the temperature of the air in which a measurement is made influences peripheral temperature is a well-known fact (Matthews, 1984; Matthews & Casteel, 1985; Matthews & Quinn, 1986). As ambient temperature drops, the peripheral temperature tends to follow it downward. Consequently, it is imperative that comparison studies of peripheral temperature be made within the same, rather well-controlled, ambient temperature, or the effect of ambient temperature may mask an important difference or produce other confusing results. If the relationship between ambient and peripheral temperatures is understood, however, peripheral temperatures may be adjusted to compensate for the effect of ambient temperature.

In a previous study, Matthews & Quinn (1986) observed a relationship between peripheral temperature and the human circadian thermal cycle. In this daily cycle (Aschoff, 1960; Deryagina & Kraevskii, 1984; Minors & Waterhouse, 1981; Weston, 1979), trunk temperature reaches a minimum near 5:00 a.m. and increases steadily until about noon. The trunk temperature rises very slightly between noon and 5:00 p.m., drops steadily after 5:00 p.m. until about midnight, and drops very slightly from midnight to 5:00 a.m.. Because observation of students is restricted to the school day, only the portion of the circadian thermal cycle between 8:00 a.m. and 4:00 p.m. is of interest. It is necessary for comparison studies of peripheral temperature to be made at identical points on the circadian thermal cycle; otherwise, measures must be corrected for the effect of the circadian thermal cycle before they are compared. If the correction is not made, the effect of the circadian thermal cycle becomes an uncontrolled source of extraneous variability, increasing the error variance of measures and masking important differences.

The foregoing comments articulate the bases for the formation of the hypotheses in this study. The hypotheses fell into three subsets. The first subset contained two hypotheses and addressed the two best-known sources of extraneous variation in peripheral temperature as a measure of anxiety. These two sources were ambient temperature and the point within the circadian thermal cycle at which measurements were made.

The investigator constructed the second set of hypotheses in an attempt to validate the use of peripheral temperature as a measure of relaxation (where relaxation was the opposite of anxiety). Support for these hypotheses would tend to reinforce the construct validity of peripheral temperature as a measure of relaxation.

Using the third set of hypotheses, the researcher sought to isolate within the various schools those correlates of peripheral temperature, corrected for ambient temperature and the circadian thermal cycle, thus beginning the search for the sources of school stress. The complete set of hypotheses follows.

<u>Correction Hypotheses--Set I</u>

1. Peripheral temperature will tend to change with the circadian thermal cycle.

2. As ambient temperature increases, peripheral temperature will tend to increase.

<u>Construct Validation Hypotheses--Set II</u>

3. Peripheral temperature corrected for the circadian thermal cycle ∖ ambient temperature is related to the curriculum being studied at the time of measurement.

4. Peripheral temperature corrected for the circadian thermal cycle and ambient temperature tends to decrease as the level of average ability of students increases.

5. Peripheral temperature corrected for the circadian thermal cycle and ambient temperature varies from school to school.

6. Peripheral temperature corrected for the circadian thermal cycle and ambient temperature will tend to vary inversely with the score on an anxiety scale which measures state anxiety.

7. Peripheral temperature corrected for circadian thermal cycle and ambient temperature will tend to increase with the teacher's satisfaction with the overall educational achievement of students.

<u>Correlates of School Stress--Set III</u>

8. Peripheral temperature corrected for the circadian thermal cycle and ambient temperature will tend to vary with:

8.1 grade level of the student;

8.2 size of the student;

8.3 sex of the student;

8.4 race of the student;

8.5 expectation of the teacher in regard to the potential of a class of students for educational achievement; and

8.6 school-wide variables, including:

8.6.1 drop-out rate,

8.6.2 expulsion rate,

8.6.3 suspension rate,

8.6.4 retention rate,

8.6.5 poverty level,

8.6.6 proportion of students qualifying for the free lunch program,

8.6.7 proportion of single-parent families, and

8.6.8 average achievement level of students.

9. Peripheral temperature corrected for the circadian thermal cycle and ambient temperature will tend to vary with the nine items comprising the Student Attitude Inventory.

METHOD

Sample

Eleven schools within the South Carolina midlands accepted the request of the researcher to participate in the study. The investigator drew upon her experience with schools in the region to select some schools which seemed particularly academically challenging and others which did not seem extremely demanding of the stud`.ts. She believed her strategy would net a variety of mean anxiety levels which could be traced back to school factors.

The term "school" denoted Grades 7 through 12 from a common attendance area, even though more than one building housed these grades. Thus, the researcher referenced a junior high school and the senior high school which was fed by the junior high school as a single school. Because the anonymity of each school was assured as a condition of the participation of the school in the study, the researcher identified every school using a letter of the alphabet; therefore, each school is referenced subsequently in this report and in all tables by an alphabetic letter.

The investigator randomly selected classes in 10 of the 11 schools from each period from a list of classes by periods. Each school had three visitations, with different classes being observed on each visit. The research team observed a total of six classes in each school in each grade because adequate staff existed to observe only two classes per period. Certain types of classes received no observation, notably classes in physical education or other classes in which the level of physical activity was presumed to be a factor which would influence peripheral temperature. In addition, the principal of School D requested that no English classes be observed. The principal was reluctant to allow disruption occasioned by the observation within English courses because of the statewide emphasis on pupil achievement in these curricula. Even in School D, with the exceptions noted, the researcher randomly selected classes for observation, although from a shortened list of courses per period.

Within each school, each participating student received a unique number. Particularly in smaller schools, when observations were made in different classes, it was possible to observe a given student two or more times in the course of the full set of observations. These repeated measures on some, but not all, students were not manageable within the normal statistical generalizations because the sampling distributions of useful statistics may not be predicted in such a sample. Thus, the researcher used a sampling procedure to assure that only one observation for each student actually found its way into the dataset which underwent analysis. From the entire set of observations on a given student, the researcher randomly selected one observation, a preferred practice over choosing the first observation for each student because that strategy would have depleted the numbers of students in classes in small schools which were observed last much more than those classes which were observed first. Keeping roughly equal numbers of students in various classes was more important for analysis than the elimination of retest bias. Retest bias appears when observations from students who have been observed previously are included for analysis. In this study, however, where peripheral temperature was being observed, retest bias was not as important as it would have been in a pencil-and-paper test.

Table 1 reveals the effect of discarding all but one observation on each student. One will note that, of 5,926 total student observations, the researcher retained only 4,097. This number (4,097) was the number of unique students who were retained for evaluation in the study.

The number of students per school ranged from 184 to 550. The grade span for each school was 6 grades, from Grade 7 through Grade 12. For comparison purposes, the researcher "forced" the courses of study in observed classes into four categories, referenced as "curricula." These curricula were: (1) language arts, including such courses as English, foreign language, and business English; (2) mathematics; (3) social studies; and (4) science.

Tables 2 through 16 show the breakdown by school of various demographic variables. Table 2 shows race and sex of participants by school. Tables 3 and 4 show the mean age and arm length (collected as a measure of the size of the participants) by school by grade. Tables 5 through 15 show the number of participants by grade and curriculum in each school, Table 16 aggregates the data in Tables 5 through 15 and reports the studywide number of participants in each grade and curriculum.

Table 1

Total, Unique, and Duplicated Student Data Records by School

School	Total	Unique	Duplicated
A	651	452	199
B	523	402	121
C	480	184	296
D	392	322	70
E	550	385	165
F	394	382	12
G	600	490	110
H	668	550	118
I	489	284	205
J	639	388	251
K	540	258	282
Total	5,926	4,097	1,829

Table 2

Participants by Race and Sex in Each School

	Race				Sex		
School	White	Black	Other	Unknown	Boys	Girls	Unknown
A	210	239	1	2	218	234	0
B	256	146	0	0	188	214	0
C	97	87	0	0	90	94	0
D	40	273	2	7	151	171	0
E	254	129	1	1	176	207	2
F	346	27	4	5	164	217	1
G	403	86	1	0	222	268	0
H	155	390	3	2	253	295	2
I	78	200	2	4	137	147	0
J	383	0	5	0	182	206	0
K	254	0	3	1	122	136	0

Table 3

Mean Age in Years of Participants by School by Grade

School	Grade 7-12	7	8	9	10	11	12
A	15.17	12.64	13.90	14.67	15.67	16.85	17.76
B	14.77	13.08	13.72	14.53	15.66	16.30	17.35
C	15.20	12.73	14.22	14.69	15.53	16.57	17.56
D	15.01	12.91	13.71	14.92	15.71	16.67	17.46
E	14.79	12.70	13.68	14.83	15.61	16.46	17.47
F	14.99	12.55	13.66	14.57	15.55	16.45	17.55
G	15.38	12.77	13.84	14.69	15.61	16.51	17.55
H	14.82	12.68	13.82	14.36	15.43	16.47	17.12
I	15.15	13.18	13.88	15.00	15.58	16.30	17.53
J	15.09	12.55	13.53	14.48	15.42	16.42	17.43
K	15.01	12.69	13.59	14.52	15.57	16.60	17.46

Table 4

Mean Arm Length in Inches of Participants by School by Grade

	Grade						
School	7-12	7	8	9	10	11	12
A	25.96	24.65	26.06	25.97	26.57	26.73	25.78
B	26.00	25.20	25.67	25.79	26.69	26.59	26.91
C	26.57	26.36	25.84	26.21	26.72	27.27	26.80
D	26.46	26.04	26.53	26.08	27.22	26.49	26.64
E	25.96	24.82	26.16	26.26	25.74	26.95	26.60
F	25.58	23.98	25.32	26.39	25.96	26.02	26.09
G	25.88	25.41	25.54	25.99	25.99	26.18	26.00
H	26.21	25.51	26.41	26.67	26.20	26.25	26.14
I	26.43	25.87	25.88	26.30	26.69	26.81	27.24
J	25.89	24.46	25.26	25.71	26.29	27.17	26.14
K	25.67	24.47	24.99	25.78	26.06	26.86	25.96

Table 5

Frequencies of Participants by Curriculum by Grade at School A

	Grade						
Curriculum	7-12	7	8	9	10	11	12
Language Arts	144	25	19	25	21	7	47
Science	109	29	32	16	1	19	12
Mathematics	76	0	34	20	18	4	0
Social Studies	123	8	22	32	2	43	16

Table 6

Frequencies of Participants by Curriculum by Grade at School B

	Grade						
Curriculum	7-12	7	8	9	10	11	12
Language Arts	157	22	35	62	8	15	15
Science	72	41	10	13	6	1	1
Mathematics	98	0	38	19	16	11	14
Social Studies	75	0	20	0	21	18	16

Table 7

Frequencies of Participants by Curriculum by Grade at School C

	Grade						
Curriculum	7-12	7	8	9	10	11	12
Language Arts	75	13	16	6	5	17	18
Science	63	13	11	7	10	19	3
Mathematics	23	0	0	17	3	1	2
Social Studies	25	7	0	5	1	7	3

Table 8

Frequencies of Participants by Curriculum by Grade at School D

	Grade						
Curriculum	7-12	7	8	9	10	11	12
Language Arts	18	0	0	4	5	5	4
Science	58	17	14	5	9	3	10
Mathematics	138	43	18	32	20	20	5
Social Studies	68	0	31	6	1	13	17

Table 9

Frequencies of Participants by Curriculum by Grade at School E

	Grade						
Curriculum	7-12	7	8	9	10	11	12
Language Arts	59	12	8	12	2	10	15
Science	26	18	7	0	0	0	1
Mathematics	159	20	23	62	45	2	7
Social Studies	141	34	23	24	14	35	11

Table 10

Frequencies of Participants by Curriculum by Grade at School F

	Grade						
Curriculum	7-12	7	8	9	10	11	12
Language Arts	164	21	36	13	53	20	31
Science	62	26	11	0	9	13	3
Mathematics	100	8	3	19	21	24	25
Social Studies	46	13	18	15	0	0	0

Table 11

Frequencies of Participants by Curriculum by Grade at School G

	Grade						
Curriculum	7-12	7	8	9	10	11	12
Language Arts	323	26	15	19	93	77	93
Science	100	0	79	21	0	0	0
Mathematics	38	14	0	24	0	0	0
Social Studies	14	0	5	1	0	8	0

Table 12

Frequencies of Participants by Curriculum by Grade at School H

	Grade						
Curriculum	7-12	7	8	9	10	11	12
Language Arts	260	86	39	69	38	22	6
Science	61	0	0	13	18	8	22
Mathematics	79	11	0	16	24	24	4
Social Studies	150	0	55	0	19	70	6

Table 13

Frequencies of Participants by Curriculum by Grade at School I

Curriculum	Grade 7-12	7	8	9	10	11	12
Language Arts	93	11	0	18	21	21	22
Science	80	19	17	21	11	11	0
Mathematics	54	9	18	5	7	3	12
Social Studies	76	26	0	5	21	3	11

Table 14

Frequencies of Participants by Curriculum by Grade at School J

Curriculum	Grade 7-12	7	8	9	10	11	12
Language Arts	167	13	30	24	34	30	37
Science	128	23	35	33	11	15	11
Mathematics	58	15	6	1	24	12	0
Social Studies	34	0	0	0	5	7	22

Table 15

Frequencies of Participants by Curriculum by Grade at School K

Curriculum	Grade 7-12	7	8	9	10	11	12
Language Arts	121	17	21	29	14	9	31
Science	52	0	16	10	10	16	0
Mathematics	32	12	0	0	8	12	0
Social Studies	73	20	0	7	14	6	6

Table 16

Aggregated Frequencies of Participants by Curriculum by Grade across All Schools

Curriculum	Grade 7-12	7	8	9	10	11	12
Language Arts	1583	247	219	281	284	233	319
Science	810	186	232	139	85	105	63
Mathematics	855	132	140	215	186	113	69
Social Studies	793	108	174	95	98	210	108
Totals	4041	673	765	730	653	661	559

Procedure

During the fall of the school year, the principal investigator visited the principals of schools from the central region of South Carolina who volunteered to participate in the research and collected schedules of classes. After excluding curricula with a preponderance of physical activity, research assistants randomly selected a sample of classes from each period for each school. The study had one school in which English classes were excluded from the population at the request of the principal. A class sampling management document (see Appendix A) provided the structure for selecting classes for observation during the various periods within each school.

From January through May of the school year, three observations occurred in each of the 11 schools, with the order of schools for observation and the order of classes for sampling being selected randomly. Before a school was visited, research assistants mailed a sampling schedule (see Appendix B) to the principal so that the teachers would be informed of class visits. To minimize the disruptions caused by data collection, teachers adhered to their regular schedule of activities as much as possible.

On visitation day, two research assistants visited each class. The researchers measured the air temperature, referenced as ambient temperature, by hanging an Enviro-Temp probe in the air for 15 to 20 minutes. Once the probe was in place, the researchers retired from the class, returning about midperiod to (1) measure the arm length and peripheral temperature at the fingertip for each student; (2) confirm the accuracy of descriptive data on the data card; (3) record the ambient temperature; and (4) administer the Self-Evaluation Questionnaire and the Student Attitude Inventory to all students, reading the items to low performing students.

While research assistants worked with the students, the classroom teacher completed the Teacher Satisfaction Rating Scale. On this instrument the teacher rated the class for potential in educational achievement and satisfaction of performance.

After students answered the attitude and anxiety scales, the research assistants collected the instruments, as well as the Teacher Satisfaction Rating Scale, and recorded the type of curriculum to which the class belonged, the ability level of the students, and the period of the class. The data collection process within a class took from 15 to 20 minutes, depending on the ability level of the students.

During the months of June and July, the principal investigator collected a number of school characteristics which she thought might have an association with finger temperature. Principals of the participating schools gave information on a school data sheet (see Appendix C) regarding school dropout, expulsion, suspension, retention rates, and test scores for Grades 7 and 10 from the Comprehensive Tests of Basic Skills and for Grades 8 and 11 in the Basic Skills Assessment Program. Because both types of tests are part of the statewide testing progr m, scores were available to the researcher through the school. For the percentage of families below the poverty level, of households headed by single parents, and of students eligible for free or reduced rate lunches, the researcher utilized data in the book Rankings of Counties and School Districts of South Carolina, 1984-85 (South Carolina Department of Education, 1986). Because this information appeared by school district, the figures used for the schools are actually district percentages. Although the school and district percentages may have varied, these data were the only such data available.

Instrumentation

Finger Temperature Indicator

Enviro-Temp, manufactured by Human Systems Measurement, was t vice used in this study to take peripheral temperature measurements. The Enviro-Temp, powered by a 9-volt battery, is a small unit having a probe with a silicon-diode tip which serves as the temperature conductor. The liquid crystal display on the instrument registers temperatures ranging from 0 degrees to 199 degrees Fahrenheit with an accuracy of ± 2 degrees Fahrenheit.

Measuring Tape

An ordinary household tape measure which was marked with the standard English system of inches was the instrument used to measure the arm length of each student from the armpit to the tip of the middle finger. This measurement was indicative of the size of the student.

State-Trait Anxiety Inventory

The State-Trait Anxiety Inventory or Self-Evaluation Questionnaire, developed by C. D. Spielberger (1970), is an instrument which measures state anxiety (a temporary condition of perceived stress) and trait anxiety (a relatively constant state of proneness to anxiety). The state anxiety subscale of the instrument was the only scale used in this research. The questionnaire consists of 40 short items--20 items for assessment of state anxiety and 20 items for assessment of trait anxiety. Items appear in counterbalanced order relative to anxiety. Because the direction of the nonanxiety items is reversed on the scoring key, high scores are indicative of high state or trait anxiety. Each scale has a range of 20 (low) to 80 (high). The questionnaire is appropriate for persons in high school, and may, in addition, be used with junior high students. The test takes from 10 to 20 minutes to administer. Reliability and validity are high; thus, the questionnaire is ranked among the best standardized paper-and-pencil anxiety measures (Buros, 1978).

Teacher Satisfaction Rating Scale

Teachers used the Teacher Satisfaction Rating Scale, developed by the researcher, to assess a class of students in regard to (1) potential for educational achievement and

(2) demonstrated educational achievement. The rating scale of the instrument ranged from 0 to 10, with 0 being the lowest rank and 10 being the highest score. There was a section in the questionnaire for teachers to report their primary teaching subjects and the grade or grades which they normally taught. A copy of this form comprises Appendix D.

Student Attitude Inventory

The researcher constructed a 10-item questionnaire from a field-tested opinionnaire to discern the opinions of students about themselves and the school which they were attending. All, except the last, of the opinion items on the test were Likert items having four response categories (strongly agree, agree, disagree, and strongly disagree). The investigator recorded each of these as a linear scale, using the values 1, 2, 3, and 4, respectively, for the possible responses. The final item was a scale of post-school ambition. The question was this: How will you continue your education after high school? The responses, in order of increasing ambition, were these: no plans, go to work, enter armed services, go to technical college or other career school, and go to college. The researcher added another response (other) to the list of answers to the final question.

Field-Testing. The researcher developed a 25-item questionnaire which was field-tested in a public high school. The investigator wanted to sample as wide a variety of different opinions as possible so that measures of average student stress in schools could be correlated with differing student opinions regarding themselves and the school. On the other hand, participating school officials expressed concern that the observations made as part of the study might require an unacceptably great amount of classroom time. Consequently, the task before the researcher was to sample as many different opinions as possible with a minimum number of items on the opinionnaire.

To shorten the test, the researcher submitted the response vectors from the field-testing to a principal-component factor analysis and set the sum of the eigenvalues for all factors in the analysis to 25, identical to the number of items. The researcher, using the varimax strategy to explain the factors as much as was feasible in terms of homogeneous item subsets, rotated the factor structure consisting of all factors with eigenvalues greater than 1.0.

Most commonly, an analyst performs a factor analysis of the items in a test to select one or more homogeneous subsets of items, each set of which becomes a subtest in a revised test. If the factor analysis is done properly, items which correlate highly with each other through the underlying factor compose the subtest (said to be unidimensional). However, this investigator used an opposite procedure in which homogeneous subsets were selected, but only one of the items from each subset was included in the final test. Further, the researcher retained those items which participated least in the rotated factor structure, thus resulting in set of items in which each represented a homogeneous subset. Consequently, the researcher sampled as many different types of opinions as possible for the number of items on the test.

In the present study, there was no intention to use the opinionnaire to make judgments about the opinions of individual respondents; therefore, using this unconventional procedure for analysis was justified. Thus, the researcher used the opinion data to determine average states of opinion within a school. Consequently, the separate item scales, with their necessarily poor reliabilities, nonetheless, had acceptable reliabilities when averaged over a large number of respondents. This perhaps surprising assertion rests upon the theory that any item response is composed of two components, one of which is the true score and the other of which is the error. The true score is the score the respondent would make if all error could be removed. Error is presumably a random component with a mean neutral response. Consequently, when added, the expected value of the summed true score is the sum of the true scores in the measures. The expected value of error is 0 because the summed random components tend to counteract each other.

The greatest source of uncertainty stemming from the analysis procedure resulted from limitations attributable to field-testing within a single school. It was possible for certain pairs of opinions to be more highly correlated in the pilot school than in the general population; however, analysis of the field-tested data could not reveal this anomaly. Consequently, the researcher discarded one of the pairs of highly correlated items because of the anomalously high correlation in the pilot school. It was possible that this item could have tapped an important correlate to school stress in the primary study if it had been retained; therefore, the procedure invoked in the analysis of field-tested data might have caused the discarding of some useful items, but that loss was unavoidable without a field test which included a variety of schools. Unfortunately, resources necessary to perform a field test using a larger number of schools were unavailable to the researcher.

Sample. The sample for the field test consisted of 91 students from a public high school in the South Carolina midlands. Students were from Grades 9 through 12, with a mean grade level of 11.1. The ages of the sample ranged from 14 to 18 years, with a mean of 16.3 years.

Results of the Factor Analysis. Through the factor analysis, the investigator located 8 factors with eigenvalues greater than 1.0. Table 17 shows the number of valid responses and the mean response for each item, its standard deviation, and the factor in which it participates most with a factor loading of at least 0.6, as well as the factor loading. The researcher marked items which did not participate in any of the 8 factors as "isolated" items.

Table 17

Summary Results of Factor Analysis of 25 Items of the Student Attitude Inventory

Item	N	Mean	Std. Dev.	Factor	Factor Loading
1	91	1.65	0.74	8	0.82
2	89	2.54	0.75	isolated	
3	91	2.52	0.77	2	0.83
4	91	1.91	0.83	7	0.72
5	91	1.71	0.58	5	0.81
6	91	2.40	0.76	2	0.79
7	91	2.71	1.11	3	-0.64
8	90	1.86	0.73	4	0.81
9	91	1.65	1.03	isolated	
10	91	2.35	0.86	3	0.75
11	90	1.67	0.69	isolated	
12	89	2.63	0.65	6	0.72
13	89	2.02	0.64	2	0.73
14	90	1.49	0.66	5	0.76
15	87	1.93	0.55	6	-0.60
16	89	2.03	0.70	4	0.73
17	90	2.56	0.67	isolated	
18	90	2.90	1.06	isolated	
19	90	1.70	0.64	7	0.73
20	88	2.03	0.86	isolated	
21	89	2.04	0.85	1	0.64
22	87	2.18	0.79	1	0.80
23	87	2.30	0.92	1	0.76
24	87	2.36	0.95	1	0.82
25	83	4.12	1.08	5	-0.65

The researcher noted that Items 2, 9, 11, 17, 18, and 20 did not load heavily on any one factor. An analysis of the communality estimates, or the extent to which the separate items were "explained" by the factor structure, revealed the pattern in Table 18.

Generally, although no isolated item loaded heavily on any factor, the set of 8 factors accounted for a substantial component of the variance of each item. Only Item 9 was outstanding in the amount of variance it retained which was not captured by the 8 factors. Consequently, this item remained in the instrument to be used in the primary study. Because they loaded most heavily on one of the 8 factors, the researcher retained Items 1, 3, 4, 5, 8, 10, 12, and 24, also.

Even though the final response to the last item concerning postschool ambition (other) was not observed in the data and would have been discarded prior to analysis if it had been observed because it did not fit nicely into the presumed scale of postschool ambition, the researcher retained the response. Both the field-tested opinionnaire (see Appendix E) and the final questionnaire (see Appendix F) appear at the end of this document.

ANALYSIS AND RESULTS

Tests of the Correction Hypotheses

The researcher tested Hypotheses 1 and 2 simultaneously and proceeded, using a multiple regression procedure with ambient temperature and the circadian thermal cycle as

Table 18

Analysis of Communality Estimates

Isolated Item	Communality
2	0.65
9	0.53
11	0.62
17	0.61
18	0.74
20	0.61

predictor variables, to analyze all 4,097 observations. Hypotheses 1 and 2 were: (1) peripheral temperature will tend to change with the circadian thermal cycle, and (2) as ambient temperature increases, peripheral temperature will tend to increase. Because measures were made roughly at 8:30 a.m., 9:30 a.m., 10:30 a.m., 11:30 a.m., 1:30 p.m. (after lunch), and 2:30 p.m., the researcher estimated the ordinate of the circadian thermal cycle for each of these times to be 3.5, 4.5, 5.5, 6.5, 7, and 7, respectively. Residualization of observed peripheral temperature on the two predictors transformed the mean of residualized peripheral temperature to 0. The researcher added the mean peripheral temperature which was observed prior to residualization to restore the temperature metric with which most readers are familiar and to avoid the use of negative numbers in tabular displays. Subsequently, "corrected peripheral temperature" became the term used to identify the residualized peripheral temperature corrected about the mean peripheral temperature. Within the hypotheses of the study, the researcher referred to this variable as "peripheral temperatu corrected for the circadian thermal cycle and ambient temperature."

The researcher performed an analysis of variance procedure to determine if the combined linear model of the circadian thermal cycle and ambient temperature accounted for a significant portion of the overall sum of squares of peripheral temperature. The summary statistics resulting from the analysis of variance procedure appear in Table 19, and correlations of the circadian thermal cycle and ambient temperature with peripheral temperature are reported in Table 20. Because the combined model was statistically significant well beyond the studywide level of significance (.05), the researcher proceeded with the analysis of the significance of each effect in the model. Clearly, both the circadian thermal cycle and ambient temperature correlated with peripheral temperature in the hypothesized direction; therefore, Hypotheses 1 and 2 were supported easily.

While some interest might have inhered in the specific rate of change of peripheral temperature with changes in ambient temperature or changes in the circadian thermal cycle, the intercorrelation of the two predictors made it impossible to isolate the independent effects of the two factors. In this research, the task for the researcher was less to specify rates of change in peripheral temperature consonant with change in ambient temperature or in the circadian thermal cycle than to remove from the peripheral temperature as much of the combined effects of the two extraneous variables as possible. Residualization of peripheral temperature on both ambient temperature and the circadian thermal cycle accomplished this task.

Tests of the Construct Validation Hypotheses

Analysis of data within a model containing other possibly significant effects becomes difficult unless an investigator

Table 19

Analysis of Variance Summary Statistics

Source	df	SS	MS	F	p > F
Model (Circadian Thermal Cycle and Ambient Temperature)	2	19,914.88	9,957.44	327.68	0.0001*
Error	4,094	124,408.08	30.39		
Total	4,096	144,322 96			

*Significant at the .05 level of significance.

Table 20

Correlations of the Circadian Thermal Cycle and Ambient Temperature with Peripheral Temperature

Variable	df	Parameter Estimates	*t* for H_o: Parameter > 0	*p* > *t*
Intercept	1	40.90	21.71	0.0001*
Circadian Thermal Cycle	1	0.14	2.15	0.0158*
Ambient Temperature	1	0.61	23.83	0.0001*

*Significant at the .05 level of significance.

can assume that the other significant effects are distributed randomly within the levels of the model. Thus, if the researcher could make the assumption that the sex, race, size, and grade level of the students are distributed randomly among the various curricula within the various schools, analysis of school and curriculum effects could proceed without regard to these variables. When that assumption cannot be made, analysis suffers. In such a case, the finding of a significant curriculum effect may be a consequence of a race or sex effect which manifests itself as a curriculum effect because of disproportionate distribution of the effect within curricula. Several ways exist to attempt management of confounded, and possibly significant, effects. One way is to perform parallel analyses within each level of the confounding variable. Another way is to attempt to estimate the effect of the confounding variable and to residualize the dependent variable to remove the effect. All of these methods introduce uncertainty into the analysis because the fact that the variables are confounded implies that the separate effects of each cannot be isolated. In a situation where sex and curriculum are confounded, residualization of the dependent variable on sex, for example, will tend almost certainly to residualize on curriculum, too, thus decreasing the opportunity to observe a significant curriculum effect. Traditionally, the problem of confounded variables in experimental studies is managed by randomly assigning students to groups. In field studies of the present type, such strategies cannot be used because the groups (classes) are formed long before the observations are made.

Still, it is not necessary for the researcher to address the contaminating effects of every variable within a set of data. Instead, it suffices to address only those effects that (1) are confounded in the model and (2) are correlated with the dependent variable. The methods used in the analysis to identify and deal with those variables which meet both of these conditions appear in the following section of this document.

An essential first step is to observe the questionable variables because those that fail to be observed cannot be managed. In the present study, the researcher observed variables like sex, race, grade level, body size, and age of the students, in addition to such main effects as school, curriculum, anxiety level, average ability of students, and overall teacher satisfaction with the educational achievement of the students. Anxiety level of students, average ability of students, and overall teacher satisfaction with the educational achievement of the students were, conceptually, continuous variables, but school and curriculum were classification variables. Particularly troublesome were those confounding variables which were distributed nonrandomly within the levels of the classification variable. An analysis of the distribution of sex, race, grade level, body size, and age of students within the levels of school and curriculum yielded the information discussed in the following paragraphs.

The analysis of variance in which school and curriculum were main effects and each possible contaminating variable was the dependent variable provided information for identifying those variables which were distributed nonrandomly within the levels of the classification main effects. Size and age of the students were continuous variables. Sex was a dichotomous variable. The researcher was able to consider race as a dichotomous variable by ignoring all races except blacks and whites. The Pearson correlation of these variables with the continuous variable, corrected peripheral temperature, identified those variable hat shared substantial association with the dependent variable.

For size, operationalized as the length of the left arm, analysis of variance produced a significant $\underline{F}$ statistic (4.52 with 43 and 3,997 $\underline{df}$), showing that student size was not distributed randomly within the levels of school and curriculum. Further study revealed that size was distributed nonrandomly among the 11 schools, among the four curricula, and within the school-by-curriculum interaction. However, the correlation between size and corrected peripheral temperature was not significant ($\underline{r}$ = -0.02 with 4,041 observations). Size, then, was dismissed as a contaminant in tests of the construct validation hypotheses.

Age of the student associated significantly with the model containing school and curriculum main effects in the analysis of variance (*F* = 16.01 with 43 and 3827 *df*). There was a nonrandom distribution of the variable among schools, curricula, and the interaction of school and curricula. Pearson's correlation between age of the student and corrected peripheral temperature attained statistical significance (*r* = 0.09 with 3871 observations), but this correlation could not be considered to be associated substantially with corrected peripheral temperature because there was less than one percent of shared variance between the two variables. Consequently, there was no contamination in the tests of the construct validation hypotheses originating from the age of the student.

Sex failed to produce a significant *F* statistic in the analysis of variance with the school-curriculum model (*F* = 1.22 with 43 and 3,992 *df*). Although the point-biserial correlation of sex and corrected peripheral temperature attained statistical significance (*r* = 0.14 with 4,036 observations), sharing 1.96 percent of their variance, the nonsignificant *F* means that sex need not be considered further as a contaminant in tests of the construct validation hypotheses.

In the analysis of variance, race produced a highly significant *F* statistic with the school-curriculum model (*F* = 48.20 with 43 and 3,953 *df*). While distributed nonrandomly among the schools (several schools were "racially identifiable" in that some were totally white and others were almost entirely black) and within the school-by-curriculum interaction, race seemed to be distributed randomly among the four curricula. The point-biserial correlation of race and corrected peripheral temperature ($\underline{r}$ = 0.08 with 3,997 observations) was statistically significant; however, the correlation was too weak to be considered as a contaminant, with less than one percent of shared variance between race and corrected peripheral temperature. Consequently, it was not necessary to consider race as a contaminant in tests of the validation hypotheses.

While other variables may have gone unobserved and may have contaminated the tests of the hypotheses in the construct validation set, the tests just reported revealed that none of the four variables tapped by the researcher as candidates for sources of contamination needed to be considered further in the tests of the construct validation hypotheses. With this fact in mind, the researcher began testing the hypotheses.

The researcher tested Hypotheses 3, 5, and 6 in a single omnibus analysis of variance test in which the dependent variable was corrected peripheral temperature. The hypotheses dealt with the relationship between corrected peripheral temperature and curriculum, school, and state anxiety. Because the slopes of the respective regression lines of the predictor variables differed significantly among the subgroups which were composed of a unique combination of school and curriculum, the investigator excluded Hypothesis 4, dealing with the average ability level of the class, and Hypothesis 7, dealing with teacher rating of satisfaction with the educational achievement of the class, from the omnibus test. There was no way that these variables could be treated as covariates in the general linear model because the correlation of these two continuous variables with corrected peripheral temperature within these cells was not homogeneous. On the other hand, the slopes of the regression of corrected peripheral temperature and the state anxiety scale were homogeneous, making the state anxiety variable a candidate for the omnibus test.

Recording of the subject (business English or general mathematics, for example) occurred at the time of the observation of peripheral temperature. The variety of subjects was so great that some schools had only a few students in certain subjects and other schools had none. Subject was an inappropriate variable, then, for comparison across schools. A new variable, curriculum, emerged by combining related subjects. Most subjects fit easily into four categories: language arts, science, mathematics, and social studies. Deletion of other subjects which did not easily subsume into larger groups (home economics, for example) became necessary. In the omnibus test of Hypotheses 3, 5, and 6, one school (School D) had too few language arts observations for the analysis; therefore, for this test alone, all language arts observations were dropped.

When only three of the four curricula were retained, the number of observations in the data set dropped from 4,097 to 2,056, still an adequate number of observations. Both school and curriculum were fixed factors in the subsequent analysis, because there was no attempt to select a random sample of schools from the entire population of schools. When the courses observed in the study were subsumed within four curricula, the intention of the researcher was to group similar courses; however, she did not expect these curricula to be a random subset of some superset of curricula, and certainly the curricula were not considered random elements of any superset. Consequently, there was no intention on the part of the investigator to generalize the results of this study to any larger population of schools than those selected nor to any curricula other than those examined in the study. This issue is crucial to a clear understanding of the analysis. If school and curriculum were random factors, whose levels in the study were random samples of larger supersets, and if the intention of the investigator was to generalize the results of the study to a well-defined population, then the appropriate error term for these factors in the forming of an F ratio in the analysis of variance would be the effect attributable to the interaction of the two random factors. In the present study, however, the researcher intended no such generalization. Instead, selection of the schools ensured the variability in the extent to which the schools provided a stressful learning environment. These schools comprised the entire population of interest; thus, such schools were fixed effects in the model. Their appropriate error term was the residual error variance. A summary of the analysis of variance in the general linear model appears in Table 21.

As the score of a student on the state anxiety subscale of the Self-Evaluation Questionnaire increased, the corrected peripheral temperature tended to decrease. The standardized regression coefficient between the state anxiety score and corrected peripheral temperature was approximately -0.027, thus supporting Hypothesis 6.

The researcher computed the least squares means for levels of the two classification variables, curriculum and school. These variables have the same interpretation in unbalanced models as arithmetical means have in balanced models. The presentation of the curriculum least squares means in Table 22 is for information only because the analysis of variance in the general linear model showed no significant differences in corrected peripheral temperature among the three curricula.

The investigator performed Tukey's hsd test on the set of school means (see Table 22). The value of the studentized range for a test of two means in the Tukey procedure, assuming equal numbers of observations in each of the 11 means, was approximately 1.485. Thus, the researcher considered pairs

Table 21

Summary of the Analysis of Variance in the General Linear Model

Source	df	SS	MS	F	p > F
Student Score on State Anxiety Subtest of *Self-Evaluation Questionnaire*	1	185.70	185.70	6.26	0.0062*
Curriculum	2	60.37	30.19	1.02	0.3618
School	10	3,220.40	322.04	10.85	0.0001*
Interaction between Curriculum and School	20	3,039.11	151.96	5.12	0.0001*
Error	2,265	67,214.56	29.68		

*Significant at the .05 level of significance.

Table 22

Least Squares Means for School and Curriculum Effects for Analysis of Variance

School	Least Squares Mean Corrected Peripheral Temperature
H	89.61
F	89.37
K	89.15
I	89.03
G	88.75
C	88.32
B	87.50
E	86.95
A	86.93
D	85.67
J	85.66

Curriculum	Least Squares Mean Corrected Peripheral Temperature
Science	88.19
Social Studies	87.79
Mathematics	87.73

of means which differed by less than 1.485 degrees of corrected peripheral temperature to be members of the same homogeneous subset of means, while means which differed more than 1.485 degrees were considered to differ significantly. The top four schools clearly differed from the bottom five schools. Table 23 identifies the homogeneous subsets of means.

The presence of the large, and very significant, curriculum by school interaction shown in Table 21 made the results of the study extremely difficult to interpret. The difficulty arose from at least two directions. The sheer number of interactions possible (53 in the Tukey hsd test, for example), each of which probably should have been examined separately, would have expanded the size of the research report well beyond what many other researchers would read. The second problem was more vexing. The presence of an interaction meant that the main effects were not simply additive. The nature of the association between the dependent variable and the main effects was quite complex. Theory building on the basis of main effects is fairly simple, but building a comprehensive theory to accommodate an interaction tends to overwhelm the theorist.

A more appealing approach to managing an interaction is to study the data to determine if the interaction may be "explained" in some way. Often, this task cannot be done, but when it is successful, a clear understanding of the nature of the relationships in a study almost always results.

Table 23

Homogeneous Subsets of Means by the Tukey hsd Test for the School Effect

J	D	A	E	B	C	G	I	K	F	H
———	———	———	———		———	———	———	———	———	———
				———	———	———				
		———	———	———	———					

On the basis of such an argument and in hope of finding an "explanation" of the interaction, the researcher, using this analysis, listed the least squares means for the 33 levels of the interaction and thus performed no post hoc comparisons on the means. Instead, the investigator departed from the step-by-step tests of the hypotheses and made new tests to "tease out" a clearer picture of the relationships underlying the data.

The researcher subdivided the data by grade (Grades 7-12) and submitted the data for each grade to an analysis of variance similar to that just reported, except that the covariate was dropped. In each grade, the exclusion of certain schools from the analysis was necessary because those schools had low numbers of students in at least one of the four curricula. The exclusions were: Grade 7 (Schools B, D, H, and G); Grade 8 (Schools H, I, and K); Grade 9 (School J); Grades 10 and 11 (School G); and Grade 12 (Schools G and K). Tables 24 through 48 are summary tables for each grade, including appropriate subsequent post hoc tests of mean differences.

Table 24 is a summary of the analysis of variance in the general linear model for school, curriculum, and the school-by-curriculum interaction for Grade 7. The mean corrected peripheral temperatures by school and by curriculum are in Table 25. Neither the means by school nor the means by curriculum differed significantly; therefore, no further tests were performed on these means. Only the interaction

Table 24

Summary of the Analysis of Variance in the General Linear Model for Grade 7

Source	df	SS	MS	F	p > F
School	6	156.30	26.05	1.20	0.3052
Curriculum	3	155.05	51.68	2.38	0.0691
Interaction between School and Curriculum	14	1,247.11	89.08	4.10	0.0001*
Error	388	8,420.15	21.70		

*Significant at the .05 level of significance.

Table 25

Ranked List of Means for School and Curriculum Effects for Analysis of Variance for Grade 7

School	N	Mean Corrected Peripheral Temperature
F	68	90.764
C	33	90.045
I	65	90.043
A	62	89.941
K	49	89.795
E	84	89.317
J	51	88.186

Curriculum	N	Mean Corrected Peripheral Temperature
Social Studies	108	91.106
Language Arts	112	89.473
Mathematics	64	89.295
Science	128	89.042

between school and curriculum attained statistical significance in this analysis. Table 26 is a ranked listing of the mean corrected peripheral temperature within each level of the interaction. Because displaying a post hoc test of mean differences which had 28 means in the list of interaction means was difficult and because the usefulness of such a test was doubtful, the researcher omitted this test for Grade 7.

The general linear model consisting of school, curriculum, and the interaction of school and curriculum, "explains" the variance of corrected peripheral temperature better in Grade 8 than in any other grade (see Table 27). While the proportion of the total variance explained by the model was approximately 14 percent in the other grades, the total explained variance in Grade 8 was fully 24 percent. There was no known reason for this difference. All factors in the model were significant (see Table 28). The significant curriculum effect for the corrected peripheral temperature in Grade 8 resulted from the surprisingly low temperatures in social studies (see Table 29). In the eighth grade, social studies consists usually of South Carolina history and American history. When the number of means is as great as those in Table 30, subdividing the means into homogeneous subgroups is usually not very useful; however, listing the means in order will permit interested reviewers to divide the means into homogeneous subgroups according to the critical value of the

Table 26

Ranked List of Means for Interaction of School and Curriculum for Analysis of Variance for Grade 7

School	Curriculum	N	Mean Corrected Peripheral Temperature
E	Social Studies	34	92.271
F	Social Studies	13	92.183
F	Science	26	91.589
F	Language Arts	21	90.872
I	Social Studies	26	90.867
C	Social Studies	7	90.835
C	Language Arts	13	90.637
A	Science	29	90.500
K	Mathematics	12	90.410
I	Mathematics	9	90.192
I	Language Arts	11	90.019
E	Mathematics	20	89.946
K	Social Studies	20	89.798
A	Language Arts	25	89.692
E	Language Arts	12	89.424
K	Language Arts	17	89.357
J	Science	23	89.235
C	Science	13	89.028
J	Mathematics	15	89.026
I	Science	19	88.859
A	Social Studies	8	88.692
F	Mathematics	8	85.494
J	Language Arts	13	85.362
E	Science	18	82.968

Table 27

Summary of the Analysis of Variance in the General Linear Model for Grade 8

Source	df	SS	MS	F	p > F
School	7	749.29	107.04	3.83	0.0004*
Curriculum	3	1,202.29	400.76	14.33	0.0001*
Interaction between School and Curriculum	16	1,319.63	82.47	2.95	0.0001*
Error	572	16,002.38	27.78		

*Significant at the .05 level of significance.

Table 28

Ranked List of Means for School and Curriculum Effects for Analysis of Variance for Grade 8

School	N	Mean Corrected Peripheral Temperature
C	27	90.554
F	68	90.389
J	71	88.952
G	99	88.355
E	61	88.150
B	103	86.799
A	107	86.539
D	63	84.746

Curriculum	N	Mean Corrected Peripher l Temperature
Science	199	89.130
Language Arts	159	88.919
Mathematics	122	87.965
Social Studies	119	83.727

Table 29

Results of Tukey's hsd Test on Pairwise Differences between School Means and Curriculum Means for Grade 8

Differences between School Means

D	A	B	E	G	J	F	C

Differences between Curriculum Means

Social Studies	Mathematics	Language Arts	Science

Table 30

Ranked List of Means for Interaction of School and Curriculum for Analysis of Variance for Grade 8

School	Curriculum	N	Mean Corrected Peripheral Temperature
F	Science	11	93.977
C	Science	11	92.645
J	Mathematics	6	91.402
F	Language Arts	36	91.074
E	Language Arts	8	90.846
E	Mathematics	23	90.531
A	Language Arts	19	90.416
A	Science	32	89.927
J	Science	35	89.908
G	Language Arts	15	89.479
F	Mathematics	3	89.347
C	Language Arts	16	89.117
B	Science	10	88.775
B	Mathematics	38	88.631
G	Social Studies	5	88.329
G	Science	79	88.143
J	Language Arts	30	87.347
F	Social Studies	18	86.999
B	Language Arts	35	86.468

table continues

Table 30 (Continued)

Ranked List of Means for Interaction of School and Curriculum for Analysis of Variance for Grade 8

School	Curriculum	N	Mean Corrected Peripheral Temperature
D	Science	14	86.408
D	Mathematics	18	86.259
A	Mathematics	34	85.659
E	Social Studies	23	85.625
E	Science	7	85.544
D	Social Studies	31	83.118
B	Social Studies	20	82.908
A	Social Studies	22	79.623

studentized range for these means. That number, at the .05 level of significance, is approximately 12.08.

The results of the analysis of corrected peripheral temperature for Grade 9 appear in Table 31. Both main effects and their interaction were significant. Data relative to the post hoc tests of both main effects are in Table 32. The significant curriculum effect for the corrected peripheral temperature for Grade 9 (see Table 33) was more difficult to explain than the effect for Grade 8. Students in mathematics classes had the lowest temperatures, significantly different from students in language arts and social studies. Apparently, according to Table 34, the course in Grade 9 that was generally most stressful was mathematics. In Grade 9, students who do not have a talent for mathematics begin the study of algebra; however, more capable students, usually in the minority, have completed a year of algebra by the time they enter Grade 9. The large interaction and the means reported in Table 34 show that stressful mathematics courses are not universal, however, because in some schools, notably School E, mathematics in Grade 9 proved to be one of the least stressful courses.

The results of the analysis of data from Grade 10 are in Tables 35 through 38. Table 35 reveals that only the school effect was significant for the corrected peripheral temperature for Grade 10. The results of the post hoc tests on the significant school effect appear in Tables 36 and 37. Curriculum was not a significant main effect in Grade 10;

Table 31

Summary of the Analysis of Variance in the General Linear Model for Grade 9

Source	df	SS	MS	F	p > F
School	9	717.69	79.74	3.11	0.0012*
Curriculum	3	443.18	147.67	5.75	0.0007*
Interaction between School and Curriculum	22	1,711.66	77.80	3.03	0.0001*
Error	637	16,351.43	25.67		
Corrected Total	671	19,339.17			

*Significant at the .05 level of significance.

Table 32

Ranked List of Means for School and Curriculum Effects for Analysis of Variance for Grade 9

School	N	Mean Corrected Peripheral Temperature
H	98	90.037
E	98	89.608
I	49	88.622
G	65	88.596
K	46	88.005
F	47	87.969
C	35	87.510
B	94	87.497
A	93	87.216
D	47	86.817

Curriculum	N	Mean Corrected Peripheral Temperature
Social Studies	95	89.708
Language Arts	257	88.719
Science	106	88.050
Mathematics	214	87.439

Table 33

Results of Tukey's hsd Test on Pairwise Differences between School Means and Curriculum Means for Grade 9

Differences between School Means

D	A	B	C	F	K	G	I	E	H
—	—	—	—	—	—	—	—		
—	—	—							
									—
—	—								
								—	—
			—	—	—	—	—	—	—

Differences between Curriculum Means

Mathematics	Science	Language Arts	Social Studies
—			
		—	—
—	—		
	—	—	—

Table 34

Ranked List of Means for Interaction of School and Curriculum for Analysis of Variance for Grade 9

School	Curriculum	N	Mean Corrected Peripheral Temperature
D	Social Studies	6	92.224
H	Science	13	91.841
C	Language Arts	6	91.232
K	Social Studies	7	91.192
F	Social Studies	15	90.950
E	Mathematics	62	90.409
H	Mathematics	16	90.244
F	Language Arts	13	90.214
C	Social Studies	5	90.102
G	Language Arts	19	89.944
A	Social Studies	32	89.805
G	Social Studies	1	89.715
H	Language Arts	69	89.649
I	Science	21	89.545
G	Mathematics	24	89.321
E	Language Arts	12	89.085
I	Social Studies	5	89.014
B	Science	13	88.893
A	Language Arts	25	88.795

table continues

Table [illegible]4 (Continued)

Ranked List of Means for Interaction of School and Curriculum for Analysis of Variance for Grade 9

School	Curriculum	N	Mean Corrected Peripheral Temperature
D	Science	5	88.495
I	Mathematics	5	88.122
E	Social Studies	24	87.800
B	Language Arts	62	87.723
I	Language Arts	18	87.576
K	Science	10	87.473
K	Language Arts	29	87.419
D	Language Arts	4	86.666
G	Science	21	86.494
C	Mathematics	17	86.236
B	Mathematics	19	85.805
A	Science	16	85.674
D	Mathematics	32	85.560
C	Science	7	85.559
F	Mathematics	19	84.080
A	Mathematics	20	82.[illegible]35

Table 35

Summary of the Analysis of Variance in the General Linear Model for Grade 10

Source	df	SS	MS	F	p > F
School	9	981.41	109.05	3.96	0.0001*
Curriculum	3	115.79	38.60	1.40	0.2413
Interaction between School and Curriculum	25	1,021.80	40.87	1.49	0.0623
Error	522	14,366.93	27.52		
Corrected Total	559	16,861.26			

*Significant at the .05 level of significance.

Table 36

Ranked List of Means for School and Curriculum Effects for Analysis of Variance for Grade 10

School	N	Mean Corrected Peripheral Temperature
H	99	89.774
B	51	89.397
K	46	89.254
I	50	89.075
A	42	88.230
E	61	87.734
C	19	87.657
F	83	87.400
D	35	85.548
J	74	85.403

Curriculum	N	Mean Corrected Peripheral Temperature
Science	85	88.483
Social Studies	98	88.479
Language Arts	191	88.453
Mathematics	186	87.155

Table 37

Results of Tukey's hsd Test to Identify Homogeneous Subsets among Schools for Grade 10

J	D	F	C	E	A	I	K	B	H
—	—							—	—
—						—	—	—	—
—	—	—	—	—	—				
		—	—	—	—	—	—	—	—

Table 38

Ranked List of Means for Interaction of School and Curriculum for Analysis of Variance for Grade 10

School	Curriculum	N	Mean Corrected Peripheral Temperature
A	Social Studies	2	93.414
D	Social Studies	1	93.291
B	Language Arts	8	92.090
E	Language Arts	2	91.105
H	Science	18	90.991
I	Mathematics	7	90.778
K	Language Arts	14	90.551
F	Science	9	90.416
I	Language Arts	11	90.414
H	Social Studies	19	90.201
C	Mathematics	3	90.161
B	Mathematics	16	90.068
H	Language Arts	38	90.062
A	Mathematics	18	89.238
D	Language Arts	5	89.198
K	Mathematics	8	89.188
C	Language Arts	5	89.137
K	Social Studies	14	88.811
I	Social Studies	21	88.746

table continues

Table 38 (Continued)

Ranked List of Means for Interaction of School and Curriculum for Analysis of Variance for Grade 10

School	Curriculum	N	Mean Corrected Peripheral Temperature
B	Science	6	88.337
A	Science	1	88.272
E	Social Studies	14	88.188
B	Social Studies	21	88.163
K	Science	10	88.113
H	Mathematics	24	88.066
E	Mathematics	45	87.443
I	Science	11	87.281
C	Science	10	87.260
F	Language Arts	53	87.164
J	Science	11	87.157
J	Language Arts	34	86.922
A	Language Arts	21	86.870
F	Mathematics	21	86.704
D	Science	9	86.510
D	Mathematics	20	83.815
J	Mathematics	24	83.273
J	Social Studies	5	81.440
C	Social Studies	1	76.718

therefore, no further tests were performed on those means. Because the interaction of the two main effects (school and curriculum) in Table 35 was not significant, the investigator performed no further tests on the means in Table 38.

Only the school effect was significant for the corrected peripheral temperature for the eleventh grade (see Table 39). The results of the post hoc tests on the significant effect appear in Tables 40 and 41. Curriculum was not a significant main effect in Grade 11; thus, no further tests were done on these means. Because the interaction of the two main effects (school and curriculum) reported in Table 42 was not significant, the researcher performed no further tests on these means, either.

The corrected peripheral temperature, as seen in Table 43, shows that only the school effect for Grade 12 was significant, as was the case for Grades 10 and 11. The results of the post hoc tests on the significant effect appear in Tables 44 and 45. Curriculum was not a significant main effect for Grade 12; therefore, no further tests on these means were performed. Table 46 is a ranked list of means for the interaction of school and curriculum. The researcher performed no further tests on these means because the interaction of the two main effects was not significant.

It is necessary to summarize the preceding tests to determine the status of Hypotheses 3 and 5. In Hypothesis 3, the investigator anticipated a significant curriculum effect. In Grade 8, curriculum proved to be related to corrected

Table 39

Summary of the Analysis of Variance in the General Linear Model for Grade 11

Source	df	SS	MS	F	p > F
School	9	1,039.91	115.54	4.00	0.0001*
Curriculum	3	118.85	39.62	1.37	0.2506
Interaction between School and Curriculum	25	1,055.62	42.22	1.46	0.0700
Error	538	15,539.40	28.88		
Corrected Total	575	18,161.86			

*Significant at the .05 level of significance.

Table 40

Ranked List of Means for School and Curriculum Effects for Analysis of Variance for Grade 11

School	N	Mean Corrected Peripheral Temperature
H	124	90.099
E	47	89.826
C	44	89.014
I	38	88.797
B	45	87.615
F	57	87.425
A	73	86.947
K	43	86.713
J	64	86.421
D	41	84.817

Curriculum	N	Mean Corrected Peripheral Temperature
Social Studies	202	88.373
Mathematics	113	87.918
Language Arts	156	87.813
Science	105	87.716

Table 41

Results of Tukey's hsd Test to Identify Homogeneous Subsets among Schools for Grade 11

D	J	K	A	F	B	I	C	E	H
———	———	———	———						———
———	———							———	———
———						———	———	———	———
———	———	———	———	———	———				
				———	———	———	———	———	———

Table 42

Ranked List of Means for Interaction of School and Curriculum for Analysis of Variance for Grade 11

School	Curriculum	N	Mean Corrected Peripheral Temperature
C	Mathematics	1	92.467
B	Science	1	92.320
E	Mathematics	2	92.139
I	Science	11	91.575
C	Social Studies	7	91.208
I	Mathematics	3	91.157
E	Language Arts	10	90.693
I	Social Studies	3	90.448
H	Language Arts	22	90.306
H	Social Studies	70	90.268
D	Science	3	89.875
C	Language Arts	17	89.774
H	Mathematics	24	89.682
E	Social Studies	35	89.446
B	Language Arts	15	89.355
H	Science	8	89.311
A	Mathematics	4	89.297
F	Mathematics	24	88.920
F	Science	13	88.801

table continues

Table 42 (Continued)

Ranked List of Means for Interaction of School and Curriculum for Analysis of Variance for Grade 11

School	Curriculum	N	Mean Corrected Peripheral Temperature
K	Mathematics	12	88.293
A	Language Arts	7	87.971
J	Language Arts	30	87.576
J	Mathematics	12	87.507
C	Science	19	87.344
K	Science	16	86.973
A	Social Studies	43	86.805
B	Mathematics	11	86.799
I	Language Arts	21	86.768
B	Social Studies	18	86.404
A	Science	19	86.396
K	Social Studies	6	86.104
D	Social Studies	13	85.655
J	Science	15	85.294
F	Language Arts	20	84.738
K	Language Arts	9	84.550
D	Mathematics	20	83.829
D	Language Arts	5	83.556
J	Social Studies	7	82.023

Table 43

Summary of the Analysis of Variance in the General Linear Model for Grade 12

Source	df	SS	MS	F	p > F
School	8	1,125.40	140.68	3.98	0.0002*
Curriculum	3	49.81	16.60	0.47	0.7039
Interaction between School and Curriculum	20	485.10	24.26	0.69	0.8413
Error	397	14,045.68	35.38		
Corrected Total	428	15,932.39			

*Significant at the .05 level of significance.

Table 44

Ranked List of Means for School and Curriculum Effects for Analysis of Variance for Grade 12

School	N	Mean Corrected Peripheral Temperature
H	38	89.576
F	59	89.014
B	46	88.778
I	45	88.102
A	75	87.529
C	26	86.953
E	34	86.487
D	36	85.423
J	70	84.132

Curriculum	N	Mean Corrected Peripheral Temperature
Mathematics	69	87.663
Language Arts	195	87.285
Science	63	87.190
Social Studies	102	86.984

Table 45

<u>Results of Tukey's hsd Test to Identify Homogeneous Subsets among Schools for Grade 12</u>

J	D	E	C	A	I	B	F	H
—				—	—	—	—	—
—	—	—	—					
	—	—	—	—	—	—	—	—

Table 46

Ranked List of Means for Interaction of School and Curriculum for Analysis of Variance for Grade 12

School	Curriculum	N	Mean Corrected Peripheral Temperature
B	Science	1	95.220
H	Social Studies	6	90.230
H	Language Arts	6	90.161
F	Science	3	90.073
H	Mathematics	4	90.009
B	Language Arts	15	89.955
B	Social Studies	16	89.657
C	Social Studies	3	89.580
I	Social Studies	11	89.273
F	Language Arts	31	89.161
H	Science	22	89.160
F	Mathematics	25	88.705
A	Social Studies	16	88.700
E	Mathematics	7	88.549
I	Mathematics	12	88.490
D	Language Arts	4	88.263
C	Science	3	88.218
A	Language Arts	47	87.379
I	Language Arts	22	87.305

table continues

Table 46 (Continued)

Ranked List of Means for Interaction of School and Curriculum for Analysis of Variance for Grade 12

School	Curriculum	N	Mean Corrected Peripheral Temperature
E	Social Studies	11	86.639
A	Science	12	86.556
C	Language Arts	18	86.422
B	Mathematics	14	86.051
D	Social Studies	17	86.011
C	Mathematics	2	85.897
E	Language Arts	15	85.549
J	Language Arts	37	85.049
D	Science	10	84.715
J	Science	11	84.646
E	Science	1	84.453
D	Mathematics	5	82.572
J	Social Studies	22	82.332

peripheral temperature. The tests revealed that the social studies curriculum was associated with a significantly lower temperature than any of the other three curricula. One possible explanation for this surprising finding was the reaction of children to the enormous amount of facts to learn and of concepts to understand in two histories: South Carolina history and American history, which are required by the South Carolina Department of Education. In Grade 9, another curriculum effect emerged. The order of the four curricula by corrected peripheral temperature was mathematics, science, language arts, and social studies. In Grade 9 where school credit became an academic issue and where the majority of students confronted algebra for the first time, the low temperature associated with mathematics was not surprising. The temperature in mathematics was significantly different from that of language arts and social studies, with science forming a homogeneous subset with every other curriculum. Curriculum was not a significant effect in Grades 7, 10, 11, and 12. The absence of curriculum as a significant effect in the upper three grades was astonishing. Examination of the means of corrected peripheral temperature by curriculum in these grades suggested that the effect of curriculum may decrease in effect as time goes by. The means for Grade 12 were almost identical.

The researcher anticipated the presence of a school effect, as was stated in Hypothesis 5. A significant difference among schools in corrected peripheral temperature emerged in Grades 8, 9, 10, 11, and 12, but not in Grade 7. The investigator noted that students in Grade 7 usually had been housed less than a year in the school where measurements were made. If a school environment were conducive to the generation of stress, probably its effect would be cumulative. Consequently, the researcher expected the environmental effect to manifest itself after the student had been immersed in that environment for a longer period of time than one year. Because the environmental effect was found in 5 of 6 grades, there was support for Hypothesis 5.

In Table 47, the researcher reports the rank order of the 11 schools in each of the six gradewise tests. The blank spaces indicate the tests in which a particular school did not participate. Clearly, School H produced the highest consistent wrist temperatures, while Schools J and D competed to produce the lowest temperatures. School I was consistently near fourth place, while School A was usually in the lower half of every ranking. The data for School G was too sparse in at least one curriculum to be used at any grades, except Grades 8 and 9; thus, its apparent consistency was not reliable. The ranking pattern across grades for all other schools was too variable for easy interpretation. However, there was no doubt that School H was in the warmest group of schools, Schools D and J were in the coolest group, and Schools I and A were in the middle group.

Table 47

School Rank in Each of the Six Gradewise Tests

	Grade					
School	7 (7)	8 (8)	9 (10)	10 (10)	11 (10)	12 (9)
H			1	1	1	1
F	1	2	6	8	6	2
B		6	8	2	5	3
G		4	4			
I	3		3	4	4	4
K	5		5	3	8	
A	4	7	9	5	7	5
C	2	1	7	7	3	6
E	6	5	2	6	2	7
D		8	10	9	10	8
J	7	3		10	9	9

NOTE: In the table, 1 indicates the school with the HIGHEST corrected peripheral temperature, and the numbers in parentheses by the grade represent the number of schools in the ranking for that particular grade level.

As stated in Hypothesis 4, the researcher anticipated that the average corrected finger temperature would decrease with the ability level of the students. According to Hypothesis 7, the researcher expected the temperature to increase with the overall satisfaction of the teachers with the educational achievement of students. Previous tests showed that corrected peripheral temperature correlated nonhomogeneously with ability levels and teacher satisfaction within school-by-curriculum cells of the design.

To test Hypothesis 4, the researcher computed the mean values for corrected peripheral temperature in each observed class because the level of the class applied to the entire group within the class, not to the individual student. After this aggregation was accomplished, the researcher computed the Pearson correlation coefficient between corrected peripheral temperature and ability level by school (see Table 48). Only three values represented ability levels in this study: 1 = lowest ability level, 2 = medium ability level, and 3 = highest ability level.

Because a significant level of association between ability level and corrected peripheral temperature was observed in only 1 of the 11 schools, Hypothesis 4 failed to be supported. The average ability level of a class in which a student is enrolled cannot be used to predict peripheral temperature.

In Hypothesis 7, the researcher, under the assumption that satisfied teachers would produce less stress in students

Table 48

Results of Tests of Hypothesis 4 within Each School

School	N Classes	Pearson's r	$p > \lvert r \rvert$
A	32	0.12	0.26
B	28	0.34	0.04*
C	20	0.30	0.10
D	20	0.18	0.22
E	22	0.21	0.17
F	31	-0.07	0.65
G	33	-0.03	0.57
H	31	-0.07	0.65
I	27	-0.44	0.99
J	26	0.11	0.30
K	26	0.16	0.22

*Significant at the .05 level of significance.

than dissatisfied teachers, predicted an association between the reported level of satisfaction of the teacher with achievement of the students. Teachers rated students on a 10-point scale, where 1 indicated the least satisfaction and 10 indicated the greatest satisfaction with the achievement of the class in which a set of measurements was made. The researcher tested Hypothesis 7 in a manner exactly parallel to that used to test the average ability level of a class. The results of the analysis appear in Table 49.

Because a significant association between satisfaction of the teacher with the achievement of the class and corrected peripheral temperature was found in only 1 of 11 schools, Hypothesis 7 failed to be supported; therefore, peripheral temperature cannot be predicted from reports of the satisfaction of teachers with achievement of a class.

Tests of Hypotheses Regarding Correlates of School Stress

Hypothesis 8

Hypothesis 8 consisted of not one hypothesis, but 13 hypotheses. These hypotheses addressed the association between corrected peripheral temperature and:

8.1 grade level of student;

8.2 size of student;

8.3 sex of student;

8.4 race of student;

8.5 expectation of the teacher in regard to the potential of a class of students for educational achievement; and

Table 49

Results of Tests of Hypothesis 7 within Each School

School	N Classes	Pearson's r	p > |r|
A	34	0.15	0.19
B	29	-0.14	0.81
C	23	-0.08	0.65
D	21	-0.24	0.86
E	27	-0.36	0.97
F	31	0.14	0.22
G	32	-0.02	0.55
H	34	0.26	0.07
I	27	0.31	0.06
J	28	0.32	0.05*
K	28	0.07	0.35

*Significant at the .05 level of significance.

8.6 a set of schoolwide variables, including:

8.6.1 dropout rate,

8.6.2 expulsion rate,

8.6.3 suspension rate,

8.6.4 retention rate,

8.6.5 poverty level,

8.6.6 proportion of students qualifying for the free lunch program,

8.6.7 proportion of single-parent families, and

8.6.8 average achievement level of st dents.

The overarching research task addressed by these hypotheses was to identify those school variables that were associated with school stress. The extent to which that task was possible was dependent on the success of corrected peripheral temperature as a measure of school stress. Although this issue will be argued later in this report, the researcher, at this point, assumed that corrected peripheral temperature was a valid measure of school stress in order to continue the analysis.

In the first four hypotheses included in Hypotheses 8, data were available on each student in the study. Testing of these hypotheses was via Pearson's r, where the observable unit was the individual student. For Hypothesis 8.5, the researcher measured the expectations of the teacher of potential educational achievement of the students for an entire class, rather than for single students, because too much of the time of the teacher would have been required. Consequently, the observable unit for the test of Hypothesis 8.5 was the class. In the eight hypotheses using schoolwide variables (Hypotheses 8.6.1 through 8.6.8) the observable unit was the school.

The first four variables in Hypothesis 8 (grade level, size, sex, and race) correlated with corrected peripheral temperature. With all correlations being expressed as Pearson's coefficients, the correlations were:

8.1 Grade level (7-12) of the student and corrected peripheral temperature correlated -0.09 with 3,995 degrees of freedom, $p < 0.0001$.

8.2 Size of the student (arm length) and corrected peripheral temperature correlated -0.01 with 3,995 degrees of freedom, $p < 0.1200$.

8.3 Sex and corrected peripheral temperature correlated 0.14 with 3,995 degrees of freedom, $p < 0.0001$, with girls associated with lower corrected peripheral temperatures.

8.4 Race and corrected peripheral temperature correlated 0.09 with 3,995 degrees of freedom, $p < 0.0001$, with black students associated with lower mean corrected peripheral temperatures.

Because the proportion of nonwhite students within the sampled schools varied over a wide range, a study of the effect of the percentage of white students on corrected peripheral temperature of both white and black students was of some interest. It seemed reasonable to expect the anxiety of a student to increase in a school in which that individual was in the minority. Consequently, the researcher expected to see the finger temperature of black students decrease with increasin. ssroom proportions of white students. On the other hand, the investigator expected the finger temperature of white students to increase with increasing proportions of white students.

To test this hypothesis, the researcher computed the mean wrist temperatures for black and white students for each school. Because School D refused the researchers random access by classes to the students and because the two private academies did not seem comparable to the public schools, the researcher excluded these three schools from the analysis. The correlation between corrected finger temperature of black students and the proportion of white students in the remaining 8 schools proved to be -0.79, with 8 observations that were significant at the 0.05 level. This finding was supportive of the use of finger temperature as a measure of anxiety. The observed mean corrected finger temperature for all black students in the study was 88.57 Fahrenheit degrees. The mean corrected temperatures of black students by school and the associated proportions of white students appear in graphic form in Figure 1.

The mean corrected peripheral temperature for white students in the study was 89.58 Fahrenheit degrees. There was no observable association between the proportion of

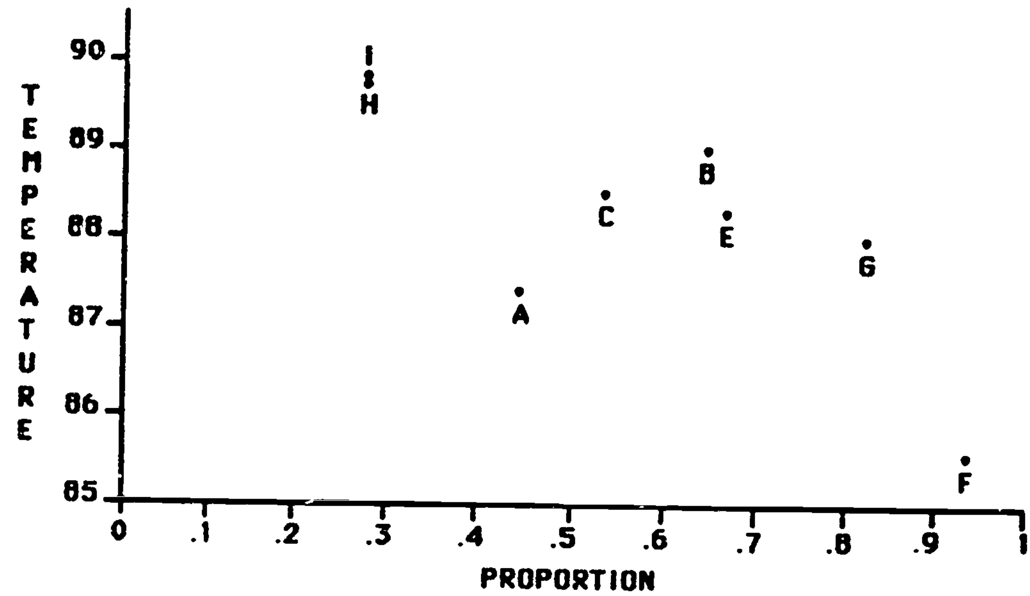

Figure 1. Scattergram of Relationship of Corrected Finger Temperature of Black Students to Proportion of White Student Enrollment.

white students and the corrected peripheral temperature of white students. It was possible that the high overall mean indicated a rather low level of anxiety in this population.

For Hypothesis 8.5, Pearson's correlation between the expectation of the teacher for the potential for educational achievement of a class and corrected peripheral temperature was -0.02 with 295 degrees of freedom, $p < 0.75$. There was no support for this hypothesis.

To study Hypotheses 8.6.1 through 8.6.8, the researcher aggregated the corrected peripheral temperature by school to compute Pearson's correlation coefficient between mean schoolwide corrected peripheral temperature and each hypothesized variable and to test for significance. The results of these tests appear in Table 50.

From the data which appear in Table 50, the researcher found no significant correlations between any of the hypothesized schoolwide variables and schoolwide corrected peripheral temperature. As a result, Hypotheses 8.6.1 through 8.6.8 failed to be supported by the data.

Hypothesis 9

Hypothesis 9 contained more than one hypothesis, also. In actuality, there were ten hypotheses which related to the nine items on the Student Attitude Inventory that was marked by each student subsequent to the measurement of wrist temperature. A subset of six hypotheses that related to the postschool plans of students comprised the last of the ten

Table 50

Pearson's Correlation Coefficients between Schoolwide Variables and Corrected Peripheral Temperature

Variable	Mean across Schools	N	Pearson's r	p > |r|
Dropout Rate	1.48	11	0.32	0.34
Expulsion Rate	0.77	11	0.24	0.47
Suspension Rate	10.78	11	-0.01	0.98
Retention Rate	7.91	11	-0.12	0.73
Poverty Level	14.01	11	0.03	0.94
Proportion of Students Qualifying for Free Lunch	45.17	11	-0.03	0.94
Proportion of Single-parent Families	21.80	10	-0.30	0.40
Average Achievement Level:				
7th Grade CTBS Battery Total	717.70	10	0.14	0.71
8th Grade BSAP Mathematics	569.00	9	-0.21	0.59
8th Grade BSAP Reading	624.78	9	-0.01	0.97
8th Grade BSAP Writing	774.78	9	0.07	0.86
10th Grade CTBS Battery Total	748.30	10	-0.05	0.89
11th Grade BSAP Mathematics	724.11	9	0.42	0.26
11th Grade BSAP Reading	701.67	9	0.34	0.37
11th Grade BSAP Writing	772.00	9	0.14	0.71

hypotheses. For the first nine hypotheses, the observable unit was the student. As described in an earlier section entitled "Instrumentation," the researcher designed the Student Attitude Inventory to tap as many different sources of variability among students as possible, in contrast to most instruments which purport to measure a single variable. The researcher chose items, as much as possible, to correlate minimally with each other. Such a procedure can be justified when using very large numbers of respondents, as was the case in this study. It was advantageous to think of the instrument as being nine separate instruments, each with rather low reliability; but the large number of respondents tended to offset the low reliability of each scale.

Hypothesis 9, then, in its first nine components, was this: There exists a relationship between corrected peripheral temperature and the responses of students to the questions:

9.1 I expect to struggle to have the career I want.

9.2 I am happy with the grades I make.

9.3 I tend to worry about things.

9.4 People generally like me.

9.5 My school believes in punishment.

9.6 Leaving school before graduation is dumb.

9.7 This school treats students fairly.

9.8 I may be too ambitious.

9.9 My principal will listen to my problems.

Students marked each of these questions with the response selected from one of four categories (Strongly Agree, Agree, Disagree, or Strongly Disagree). The researcher coded each response as 2, 1, -1, and -2, respectively, and tested each response by using the analysis of variance with post hoc tests for mean differences where appropriate.

In the analysis of variance performed for each of the first 9 components of Hypothesis 9, the researcher found that the _F_ statistic for 6 components (9.1, 9.3, 9.6, 9.7, 9.8, and 9.9) was not significant (see Tables 51, 54, 59, 60, 61, and 62). Due to this lack of significance, no further tests cn the mean corrected peripheral temperature for each category of response occurred.

The analysis of data relative to Hypotheses 9 indicated a significant _F_ statistic for 3 of the 9 subhypotheses (9.2, 9.4, and 9.5), making it necessary to conduct post hoc tests on the means for each category of response and for corrected peripheral temperature. The results of each analysis of variance and of Tukey's hsd tests are in Tables 52, 53, 59, 60, 61, and 62.

Finally, in Hypothesis 9.10, the investigator sought to find the relationship between corrected peripheral temperature and plans of students after leaving high school. Again, the observable unit was the student. The researcher tested the six subdivisions (9.10.1 through 9.10.6) that composed Hypothesis 9.10 by examining the relationship between corrected

Table 51

Analysis of Variance Summary Table for Hypothesis 9.1: I expect to struggle to have the career I want.

Source	*df*	Sum of Squares	Mean Square	*F*	*p* > *F* | H_o
Response	3	95.52	31.84	1.07	0.3600
Error	3,995	117,523.85	29.72		

Table 52

Analysis of Variance Summary Table for Hypothesis 9.2: I am happy with the grades I make.

Source	*df*	Sum of Squares	Mean Square	*F*	*p* > *F* | H_o
Response	3	320.89	106.96	3.61	0.0100*
Error	3,995	117,857.42	29.62		

*Significant at the .05 level of significance.

Table 53

Tukey's hsd Test Ranked Mean Corrected Peripheral Temperature by Response Category for Hypothesis 9.2

	Response Category			
	Strongly Agree	Agree	Strongly Disagree	Disagree
Mean Corrected Peripheral Temperature	88.73	88.95	89.36	89.49
N	317	1,653	422	1,591

Critical Value of Studentized Range = 3.64
Mean Square Error = 29.62
Degrees of Freedom = 3,979
Level of Significance = 0.05

	Mean Differences			
	Strongly Agree	Agree	Strongly Disagree	Disagree
Strongly Agree		0.22	0.63	0.77*
Agree	-0.22		0.41	0.54
Strongly Disagree	-0.63	-0.41		0.14
Disagree	-0.77*	-0.54	-0.14	

*Indicates significant mean difference at the .05 level of significance.

Table 54

Analysis of Variance Summary Table for Hypothesis 9.3: I tend to worry about things.

Source	df	Sum of Squares	Mean Square	F	p > F | H_0
Response	3	166.30	55.43	1.87	0.1300
Error	3,982	117,984.07	29.63		

Table 55

Analysis of Variance Summary Table for Hypothesis 9.4: People generally like me.

Source	df	Sum of Squares	Mean Square	F	p > F | H_0
Response	3	334.33	111.44	3.77	0.0102*
Error	3,977	117,540.79	29.56		

*Significant at the .05 level of significance.

Table 56

Tukey's hsd Test Ranked Mean Corrected Peripheral Temperature by Response Category for Hypothesis 9.4

	Response Category			
	Agree	Disagree	Strongly Agree	Strongly Disagree
Mean Corrected Peripheral Temperature	89.03	89.64	89.68	89.87
N	2,929	229	766	57

Critical Value of Studentized Range = 3.64
Mean Square Error = 29.56
Degrees of Freedom = 3,977
Level of Significance = 0.05

	Mean Differences			
	Agree	Disagree	Strongly Agree	Strongly Disagree
Agree		0.61	0.65*	0.84
Disagree	-0.61		0.05	0.23
Strongly Agree	-0.65*	-0.05		0.19
Strongly Disagree	-0.84	-0.23	-0.19	

*Indicates significant mean difference at the .05 level of significance.

Table 57

Analysis of Variance Summary Table for Hypothesis 9.5: My school believes in punishment.

Source	df	Sum of Squares	Mean Square	F	p > F | H_o
Response	3	429.57	143.19	4.84	0.0023*
Error	3,971	117,517.42	29.59		

*Significant at the .05 level of significance.

Table 58

Tukey's hsd Test Ranked Mean Corrected Peripheral Temperature by Response Category for Hypothesis 9.5

	Response Category			
	Agree	Disagree	Strongly Disagree	Strongly Agree
Mean Corrected Peripheral Temperature	88.87	88.93	89.35	89.54
N	1,809	264	84	1,818

Critical Value of Studentized Range = 3.64
Mean Square Error = 29.59
Degrees of Freedom = 3,971
Level of Significance = 0.05

	Mean Differences			
	Agree	Disagree	Strongly Disagree	Strongly Agree
Agree		0.06	0.49	0.67*
Disagree	-0.06		0.42	0.61
Strongly Disagree	-0.49	-0.42		0.19
Strongly Agree	-0.67*	-0.61	-0.19	

*Indicates significant mean difference at the .05 level of significance.

Table 59

Analysis of Variance Summary Table for Hypothesis 9.6: Leaving school before graduation is dumb.

Source	df	Sum of Squares	Mean Square	F	p > F | H_o
Response	3	56.18	18.73	0.63	0.6000
Error	3,981	118,389.38	29.72		

Table 60

Analysis of Variance Summary Table for Hypothesis 9.7: This school treats students fairly.

Source	df	Sum of Squares	Mean Square	F	p > F | H_o
Response	3	103.43	34.48	1.16	0.3200
Error	3,970	117,507.54	29.60		

Table 61

Analysis of Variance Summary Table for Hypothesis 9.3: I may be too ambitious.

Source	df	Sum of Squares	Mean Square	F	$p > F \mid H_0$
Response	3	132.77	44.26	1.50	0.2100
Error	3,960	117,206.47	29.60		

Table 62

Analysis of Variance Summary Table for Hypothesis 9.9: My principal will listen to my problems.

Source	df	Sum of Squares	Mean Square	F	$p > F \mid H_0$
Response	3	33.98	11.33	0.38	0.7700
Error	3,965	118,177.22	29.81		

peripheral temperature and the response of the student to plans after school. Possible responses were:

9.10.1 uncertainty,

9.10.2 work,

9.10.3 armed services,

9.10.4 technical college or other career school,

9.10.5 college, and

9.10.6 other plans (a completion item).

Examples of responses to Hypothesis 9.10.6 (other plans) included such items as getting married, preparing for a career in professional sports, and becoming an entertainer (singer, dancer, or instrumentalist).

The investigator computed point-biserial correlation coefficients for the tests of Hypotheses 9.10.1 through 9.10.6 by assigning the numeral 1 to each positive response and 0 to every negative response when computing the Pearson correlation coefficient. The first four components (9.10.1, 9.10.2, 9.10.3, and 9.10.4) proved to have no support; however, the last two subhypotheses (9.10.5 and 9.10.6) were supported very weakly. The results for each component of Hypothesis 9.10 appear in Table 63.

Table 63

Analys_s of Variance Summary Table for Hypotheses 9.10.1 through 9.10.6

Hypothesis	df	r	p > F
9.10.1	3,994	0.001	0.950
9.10.2	3,994	0.019	0.230
9.10.3	3,995	0.020	0.110
9.10.4	3,995	0.007	0.640
9.10.5	3,995	-0.040	0.010*
9.10.6	3,995	-0.049	0.002*

*Significant at the .05 level of significance.

DISCUSSION

Because the primary goal of the study was to explore the construct validity of corrected peripheral temperature as a measure of school stress, this section assesses the findings of the study in terms of that goal. The report contains findings which support the assertion of construct validity.

First, the evidence for corrected peripheral temperature as a measure of some underlying variable or variables clearly supports Hypothesis 5, showing that schools differ in mean corrected peripheral temperature. However, this study has not identified all of the correlates of this variable (or variables). The schools differ in mean corrected peripheral temperature, but the picture of the constructs which underlie this variation is unclear.

The best evidence that the schoolwide differences in corrected peripheral temperature actually may be attributed to within-school factors appears in systematic gradewise findings. In Grade 7, when most respondents were new to their schools, there was no observation of a school effect on temperature. In higher grades, however, the school effect appeared and tended to grow through the grades. Probably, the power of schoolwide factors to influence corrected peripheral temperature is small, but persistent, requiring more than a single year to produce pronounced differences. Within the six years of experience common to those in Grade 12 the researcher sees clearly this weak, persistent influence of the significant school effect.

The troublesome interaction between curriculum and school likely owes its existence to the differential power of persons, such as teachers and department heads, to adjust the difficulty of curriculum. It is no secret that, while middle school is an arena for experimentation by students, it also allows teachers greater latitude in defining and implementing coursework. In high school, on the other hand, graduation requirements, community expectations, the level of skills essential to postsecondary success, and widespread consensus or course and curriculum content tend to homogenize curricular offerings. In middle school, curriculum managers are free to structure courses in science, for example, which are more or less ambitious in terms of projected student skills or knowledge levels. A high school chemistry class, on the other hand, consists of a much better defined body of learnings, skills, and conventions, the absence of any of which would be readily apparent to seasoned chemistry teachers. The argument here is that the levels of the curriculum variable almost certainly were more uniform across schools in the higher grades. This assertion, generally true, does not apply, however, to the social studies course in Grade 8, forced by regulations to be relatively homogeneous across South Carolina. If other middle school coursework had been as closely parameterized by regulations as the social studies course in Grade 8, the curriculum-by-school interaction probably would not have been observed. When the sample was studied one grade at a time, the interaction weakened as the grade level increased, losing statistical significance in the three upper grades and virtually disappearing in Grade 12.

Whereas no curriculum effect is observed in the omnibus test across all grades, two significant curriculum effects emerge when the data are studied a grade at a time. In Grade 8, the coolest average temperatures characterize students in social studies classes. Such classes use a curriculum which, using two different books, combines South Carolina history and United States history in a single, very rigorous course. Furthermore, virtually all students in Grade 8 must study this course in social studies, in contrast to other grades where social studies is taught far more idiosyncratically.

In Grade 9, where average students first encounter abstract math in the form of algebra, a curriculum effect emerges once again, with math curricula associating with the lowest temperatures. This finding will surprise very few educators.

The significant correlation between race and corrected peripheral temperature (r = 0.09) is quite weak. The more interesting finding is the correlation between corrected peripheral temperatures of black students and the proportion of white students in the school (r = -0.79). As the proportion of white students grew, the stress on black students increased and temperatures fell. The fact that no similar correlation between temperatures of white students and the proportion of black students emerged may be attributable to the fact that the whites, though in the minority in some schools, nonetheless remain in the political majority and have strong role models of the same race in places of authority at school, as virtually everywhere else.

It was evident in this study that the girls exhibited lower peripheral temperatures (indicating higher stress) than did the boys. This fact is supportive of previous research and is suggestive of a tendency toward stress among girls as the more disempowered sex.

Although grade level and corrected peripheral temperature are correlated negatively, as hypothesized, this association is extremely weak ($r = -.09$), albeit significant statistically. This association cannot be used to claim that schoolwork stiffens in its demands on upperclassmen. To the contrary, it is supportive of remarkably uniform levels of pressure across grades.

At this point, a recapitulation of findings is helpful to answer the central question of the study: How useful a measure of stress is corrected peripheral temperature?

The researcher advanced Hypotheses 3 through 7 to test the construct validity of corrected peripheral temperature. These hypotheses will be reexamined briefly.

With the exceptions and caveats already advanced in this section, there were observations of systematic differences in corrected peripheral temperature among the curricula. Colder temperatures associated with social studies in Grade 8 and mathematics in Grade 9, were consistent with the hypothesis.

Many educators would agree that bright pupils are treated differently from their peers. Generally, teachers grade bright students on performance, average classes on some combination of performance and effort, and less capable classes almost exclusively on effort. The researcher expected the performance-driven upper classes to experience more stress than other classes; however, the hypothesized association did not appear in the data. In retrospect, it is possible that the hypothesis itself is invalid. In this study, while a positive finding would have been relatively easily interpreted, the negative finding is more ambiguous. It is a tenable position that brighter students find performance relatively easy to display. Moreover, the observation of the ability level of a class may have been flawed. Ability level was observed and recorded by technicians who visited the classes. The ability had three levels, 1-3. In each school, Level 3 was highest, but the variance in schools was sufficiently great that Level 3 students in one school likely would have been Level 2 students in another school in the study.

Consequently, the variable failed to be as reliable as the researcher would like for it to have been.

The difference in corrected peripheral temperature from school to school is abundantly clear: corrected peripheral temperature measures a palpable but as yet unidentifiable characteristic in totality of the school. This study failed to explain all of the variation among schools, but another attempt with a new set of variables as candidates for correlates of corrected peripheral temperature may succeed.

The significant, but very weak, association between a commonly used anxiety scale and corrected peripheral temperature seems to prove that the two measures are measuring quite different constructs, even though some association exists between them. The pencil-and-paper scale used in this study did not differentiate the schools in the study, while the corrected peripheral temperature clearly did differentiate the schools. The researcher selected the schools to guarantee as wide a variation in school environments as possible. The failure of the state anxiety scale to demonstrate a school effect is surprising. Undoubtedly, it is a given fact that stress is a concept with many factors to it. In the opinion of this researcher, the kind of stress likely to manipulate finger temperature is apprehension, while the items on the state anxiety scale suggest other factors as well, such as feelings of inferiority, lack of confidence, distractibility, and indecisiveness. The useful performance of the state anxiety scale cannot be doubted, but it apparently does not tap the factor or factors which caused the school effect in corrected finger temperature. This research, unfortunately, tapped that factor or factors, but did not identify them.

It seemed entirely reasonable, _a priori_, to expect that the satisfaction of the teacher with the performance of a class would modify the stress level of that class and, therefore, the average finger temperature of the group. The expected effect was _not_ found, but, _a posteriori_, the failure does not seem very surprising. The slow growth of the school effect across the six grade levels studied suggests that the factors which influence finger temperature, on the average, are subtle, persistent, and relatively ineffective in the first year. The more generic issue may be, not the satisfaction of the teacher with a class, but the congruence between average student performance and overall expectations of the faculty. Unfortunately, no data were collected to test this possibility.

The researcher collected a little more evidence for contruct validity in the final hypotheses. The findings of this study relative to the correlation between sex and corrected finger temperature are supportive, although very weakly, of previous research showing that girls exhibit more stress than boys. Because black students may be expected to suffer stress in predominantly white schools, the best evidence for the construct validity of corrected peripheral temperature as a measure of stress is in the correlation between the finger temperature of black students and the proportion of white students in a school. A researcher would expect stress to increase in higher grades in school; and, in fact, peripheral temperature was found to drop significantly, but very weakly, in these upper grades.

The overall performance of corrected peripheral temperature as a measure of stress is unsatisfactory. Where tabulated corrected peripheral temperature supports hypotheses, correlates with standard instruments, or reproduces previous research, it does so too weakly to remain a candidate for measurement of stress. The necessity to adjust peripheral temperature for ambient temperature and the point in the circadian thermal cycle makes the measure unwieldy. The adjustment is emphatically essential, however. Very likely, some previously reported claims that black students have higher peripheral temperatures are, in fact, consequences of the finding of this study that black students prefer warmer classrooms than do white students. This researcher believes this effect is socioeconomic, rather than racial; but in our sample, socioeconomic status and race are closely associated.

The most intriguing finding of the study is the largely unexplained school effect on corrected peripheral temperature. The greatest frustration is the difficulty in formulating hypotheses to test the construct validity of a measure of stress. Stress has an amorphous, ambiguous formlessness about it which seems to defy the researcher who tries to state a hypothesis in which two groups will differ predictably in their average level of stress. The best construct validation hypotheses are tautologies. For example, when testing a mathematics achievement measure, a researcher would expect algebra students in Grade 8 to outperform their general mathematics peers. The two groups can be tested with confidence that, if the measure is valid, the algebra students will have a higher mean score than the general mathematics group. That the two groups will differ in the hypothesized direction is tautological. The present research has suffered from the paucity of such perceived tautologies with regard to stress. Identification of subgroups which should vary predictably in terms of average stress has proven quite difficult.

The phenomenon of a drop in peripheral temperature at times of great stress is well known by every performer. The temporarily icy fingertips of a bride leaving the wedding chapel, the freezing hands of a piano student prior to a public recital, and the cold feet of soldiers before battle are all part of the common experience of mankind. In all of these situations, persons can be expected to experience apprehension and stress. However, although every former pupil easily can summon stressful memories from school days, the stressful situations rarely generalize to identifiable groups and patterns. Many students recall experiencing stress before examinations, but both well-prepared students and those students who are disinterested may experience less than normal levels of stress. The entire group, then, may have mean stress levels barely different from regular classroom norms.

The large school effect on corrected peripheral temperature is particularly tantalizing to the researcher. If that large an effect could be attributed unambiguously to school stress, then corrected peripheral temperature would be clinically reliable as a measure of stress. Already, this research effort has devised strategies to correct peripheral temperature for ambient temperature and the point in the circadian thermal cycle. Perhaps another factor, which varies from school to school and is the genesis of the observed school effect, has yet to be discovered. Perhaps the removal of its shared variance from peripheral temperature would produce a corrected peripheral temperature which will correlate more strongly with other instruments which purport to measure stress.

Until such further development, however, despite its intuitive appeal as a physiological measure of a subjective, psychological construct, peripheral temperature may not be used with demonstrable confidence in schools as a measure of stress.

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APPENDIX A

Class Sampling Management Document

			Date
School	______________	Observation #1	________
District	______________	Observation #2	________
Principal	______________	Observation #3	________
Counselor	______________		

	Period					
Grade	1	2	3	4	5	6
7						
8						
9						
10						
11						
12						

APPENDIX B

Sampling Schedule

Principal ______________________ Date ______________

Contact Person ____________________ School ____________

Periods	Classes
1	____________________
	____________________
2	____________________
	____________________
3	____________________
	____________________
4	____________________
	____________________
5	____________________
	____________________
6	____________________
	____________________

APENDIX C

School Data Sheet

Date ________________

Name of School ______________________________________

Name of Principal ____________________________________

Directions: Please complete the following information from your school for this research study. The factors listed below will be examined in relationship to the wrist temperatures collected earlier.

1. Dropout Rate _______% 2. Suspension Rate _____%

3. Expulsion Rate _____% 4. Retention Rate ______%

5. Comprehensive Tests of Basic Skills

   Total Average Mean Standard Score:

   Seventh Grade ______

   Tenth Grade ______

6. Basic Skills Assessment Program

   Percentage of Students Meeting Standard:

   Eighth Grade Math ________

   Reading ________

   Writing ________

   Eleventh Grade Math ________

   Reading ________

   Writing ________

APPENDIX D

Teacher Satisfaction Rating Scale

Directions: Please rate your assessment of the potential of your students, on the average, for educational achievement. Use a scale of 0 to 10, where 0 means no potential and 10 means maximum potential.

_____ Overall rating of students' potential for educational achievement.

Directions: Please rate your satisfaction with the extent to which your students, on the average, demonstrate educational achievement. Use a scale of 0 to 10, where 0 means complete dissatisfaction and 10 means total satisfaction.

_____ Overall rating of my satisfaction with the educational achievement of my students.

Directions: Please list your primary teaching subject.

____

Directions: Please list the grade or grades that you normally teach.

____

APPENDIX E

Student Attitude Inventory
(Field-Tested Instrument)

Age _____

Grade _____

Directions: Answer each question below by marking the response which best reflects your opinion.
Example: President Reagan is an honest man.
Strongly Agree Agree Disagree Strongly Disagree
If you believe the President is very honest, mark "Strongly Agree." If you believe he is generally, but not very, honest, mark "Agree." If he is a little dishonest, in your opinion, mark "Disagree." If he is quite dishonest, mark "Strongly Disagree."

1. I expect to struggle to have the career I want.

   Strongly Agree Agree Disagree Strongly Disagree

2. Teachers expect too much of students in this school.

   Strongly Agree Agree Disagree Strongly Disagree

3. I am happy with the grades I make.

   Strongly Agree Agree Disagree Strongly Disagree

4. I tend to worry about things.

   Strongly Agree Agree Disagree Strongly Disagree

5. People generally like me.

   Strongly Agree Agree Disagree Strongly Disagree

6. My parents are happy with my grades.

   Strongly Agree Agree Disagree Strongly Disagree

7. I wish my family would move.

   Strongly Agree Agree Disagree Strongly Disagree

8. My school believes in punishment.

   Strongly Agree Agree Disagree Strongly Disagree

9. Leaving school before graduation is dumb.

Strongly Agree   Agree   Disagree   Strongly Disagree

10. This school treats students fairly.

Strongly Agree   Agree   Disagree   Strongly Disagree

11. I am happy with myself.

Strongly Agree   Agree   Disagree   Strongly Disagree

12. I may be too ambitious.

Strongly Agree   Agree   Disagree   Strongly Disagree

13. My teachers are pleased with me.

Strongly Agree   Agree   Disagree   Strongly Disagree

14. I have friends in this school.

Strongly Agree   Agree   Disagree   Strongly Disagree

15. My parents like this school.

Strongly Agree   Agree   Disagree   Strongly Disagree

16. This school places demands on students.

Strongly Agree   Agree   Disagree   Strongly Disagree

17. I have too much homework.

Strongly Agree   Agree   Disagree   Strongly Disagree

18. I wish I could transfer to another school.

Strongly Agree   Agree   Disagree   Strongly Disagree

19. Students in this school tend to compete with each other.

Strongly Agree   Agree   Disagree   Strongly Disagree

20. The school sponsors enjoyable activities.

Strongly Agree   Agree   Disagree   Strongly Disagree

21. I can usually find an adult who will listen.

Strongly Agree   Agree   Disagree   Strongly Disagree

22. I believe my teachers are on my side.

Strongly Agree   Agree   Disagree   Strongly Disagree

23. The principal is a friend to students.

Strongly Agree   Agree   Disagree   Strongly Disagree

24. My principal will listen to my problems.

Strongly Agree   Agree   Disagree   Strongly Disagree

25. How will you continue your education after high school? (Check one.)

_____ No plans.

_____ Go to work.

_____ Enter armed services.

_____ Go to technical college or other career school.

_____ Go to college.

_____ Other. ______________________________
(Please specify.)

APPENDIX F

Student Attitude Inventory

Name ______________________ Date __________

School ______________________ Age __________

Subject ______________________ Sex M F (Circle)

Grade __________ Race W B O (Circle)

Directions: Answer each question below by marking the response which best reflects your opinion.
Example: President Reagan is an honest man.
Strongly Agree Agree Disagree Strongly Disagree
If you believe the President is very honest, mark "Strongly Agree." If you believe he is generally, but not very, honest, mark "Agree." If he is a little dishonest, in your opinion, mark "Disagree." If he is quite dishonest, mark "Strongly Disagree."

1. I expect to struggle to have the career I want.

   Strongly Agree Agree Disagree Strongly Disagree

2. I am happy with the grades I make.

   Strongly Agree Agree Disagree Strongly Disagree

3. I tend to worry about things.

   Strongly Agree Agree Disagree Strongly Disagree

4. People generally like me.

   Strongly Agree Agree Disagree Strongly Disagree

5. My school believes in punishment.

   Strongly Agree Agree Disagree Strongly Disagree

6. Leaving school before graduation is dumb.

   Strongly Agree Agree Disagree Strongly Disagree

7. This school treats students fairly.

   Strongly Agree Agree Disagree Strongly Disagree

8. I may be too ambitious.

Strongly Agree   Agree   Disagree   Strongly Disagree

9. My principal will listen to my problems.

Strongly Agree   Agree   Disagree   Strongly Disagree

10. How will you continue your education after high school? (Check one.)

_____ No plans.

_____ Go to work.

_____ Enter armed services.

_____ Go to technical college or other career school.

_____ Go to college.

_____ Other. ______________________________
(Please specify.)