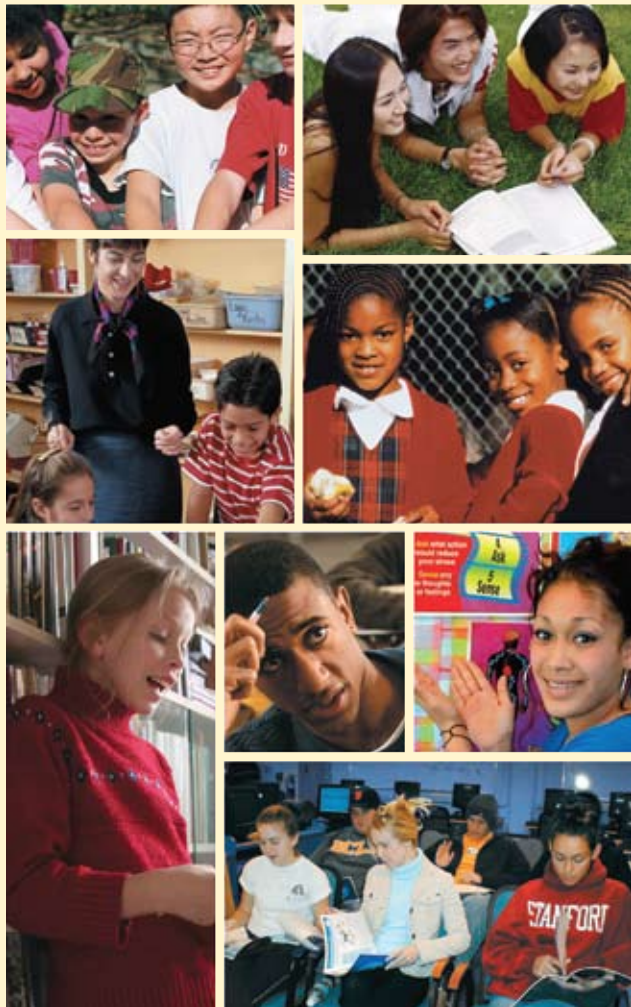


Reducing Test Anxiety and Improving Test Performance in America's Schools



TestEdge Program

Based on 16 years of scientific research, the TestEdge program teaches a set of easy-to-use tools and techniques that enable students to reduce stress and test anxiety while self-generating an optimal psychophysiological state for improved learning and academic performance.



SUMMARY OF RESULTS FROM THE TESTEDGE NATIONAL DEMONSTRATION STUDY

Raymond Trevor Bradley, Ph.D., Rollin McCraty, Ph.D., Mike Atkinson, Lourdes Arguelles, Ph.D., Robert A. Rees, Ph.D., and Dana Tomasino

Recent advances in neuroscience are highlighting connections between emotion, social functioning, and decision making that have the potential to revolutionize our understanding of the role of affect in education. In particular, the neurobiological evidence suggests that the aspects of cognition that we recruit most heavily in schools, namely learning, attention, memory, decision making, and social functioning, are both profoundly affected by and subsumed within the processes of emotion

—Immordino-Yang & Damasio (2007: 3)¹

This Executive Summary provides an overview of the purpose, research methods, and major findings of the TestEdge National Demonstration Study, conducted by researchers at the Institute of HeartMath in collaboration with faculty and graduate students at Claremont Graduate University.

Study's Purpose

The study's primary purpose was to investigate the efficacy of the TestEdge program in reducing stress and test anxiety and improving emotional well-being, quality of relationships, and academic performance in public school students. This involved determining the magnitude, correlates, and consequences of stress and test anxiety in a large sample of students and investigating the degree to which an intervention with TestEdge had a positive effect on students in an experimental group when compared to those in a control group. A second programmatic purpose was to characterize the implementation of the program in relation to its receptivity, coordination, and administration in a wide variety of school systems with diverse cultural, administrative, and situational characteristics.

This summary is excerpted from the full report, available at: www.heartmath.org/research/e-books.

TestEdge Program

For the purposes of this study, both teachers and students received instruction in HeartMath tools and techniques through the Resilient Educator and TestEdge programs, respectively. Used as the intervention in this study, these programs were developed by the Institute of HeartMath to help students and teachers reduce stress and test anxiety, improve test and academic performance, and enhance emotional and relational competence. The programs are based on 15 years of scientific research on the psychophysiology of learning and performance, emotional dynamics, and heart-brain communication. The programs teach a set of easy-to-use positive emotion refocusing and restructuring techniques that enable teachers and students to self-regulate stress, test anxiety, and other emotional impediments to learning and performance.

The basis of the effectiveness of the techniques is that they enable the individual to self-activate a specific, scientifically measurable state of optimal function, termed *psychophysiological coherence*. Research has shown that psychophysiological coherence is characterized by increased synchronization in nervous system activity, increased emotional stability, and improved cognitive and task performance.

The TestEdge program has been successfully implemented in schools throughout the U.S. and in some foreign countries; pilot studies have shown associated improvements in student standardized test scores, passing rates, and psychosocial functioning. This study marks the first time that the efficacy of the TestEdge program has been evaluated in a large-scale implementation.

Study's Hypotheses

The study tested two major hypotheses. The first is that enhanced competence in emotional management through learning and practicing the TestEdge tools would result in significant improvements in student emotional self-regulation and psychophysiological coherence. These changes would produce a marked reduction in test anxiety, which, in turn, would generate a corresponding improvement in academic and test performance. Secondly, as a result of the improvement in student emotion regulation skills, it was also expected that there would be associated improvements in stress management, emotional stability, relationships, and overall student well-being, as well as in classroom climate, organization, and function.

Research Design and Methods

To investigate the veracity of these hypotheses, two studies were conducted, each with different research objectives and designs. The first, the primary study, focused on an in-depth investigation of students at the tenth grade level. It

was designed as a quasi-experimental, longitudinal field study, involving pre- and post-intervention panels of measurement within a multi-methods framework.

For the primary study, extensive quantitative and qualitative data were gathered using survey questionnaires, interviews, and structured observation, and an assessment of student drawings, along with student test scores from two California standardized tests—the California High School Exit Examination (CAHSEE) and the California Standards Test (CST). In addition, an electrophysiological sub-study was conducted on a randomly stratified sample of students from both schools. Utilizing measures of heart rate variability (beat-to-beat change in heart rate), this controlled laboratory experiment investigated the degree to which students had learned the techniques taught in the TestEdge program by providing an objective measurement of their ability to shift into the psychophysiological coherence state prior to taking a stressful test.

The secondary study consisted of a series of qualitative investigations to evaluate the accessibility, receptivity, coordination, and administration of the program across elementary, middle, and high schools and in school systems with diverse ethnocultural, socioeconomic, administrative, and situational characteristics. We employed a case study approach to evaluate the implementation of the TestEdge program in nine schools in eight different states (California, Delaware, Florida, Ohio, Maryland, Texas, Wisconsin, and Pennsylvania). Age-appropriate versions of the TestEdge program were delivered to selected classrooms, covering grades 3 through 8 and grade 10. Observational and interview data were gathered to provide information on best practices and potential difficulties when implementing interventions such as TestEdge in widely diverse school settings.

Research Sites and Participants

The primary study involved the entire tenth grade populations of two large high schools in Northern California. One high school was randomly selected as the intervention school, while the other served as the control school.

Schools and Participants

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While the selected schools were matched as closely as possible on academic performance and key sociodemographic factors, there were some differences in the measurement of academic performance and ethnicity at baseline. Altogether, a total of 980 students participated in the primary study, of which 636 (53% male, 47% female) were in the experimental group and 344 (40% male, 60% female) were in the control group.

Intervention

The Resilient Educator program was delivered to teacher participants in a one-day workshop to provide them with a working familiarity with the HeartMath tools and techniques prior to their beginning classroom instruction of the TestEdge program. Teachers then delivered the TestEdge program to students during the Spring 2005 semester. In the program, students learned and practiced specific emotional management techniques to aid them in more effectively handling stress and challenges, both at school and in their personal lives. They were also taught how to apply these techniques to enhance various aspects of the learning process, including test preparation and test-taking. Both the student and teacher programs included use of the Freeze-Framer [now emWave PC] technology, a heart rhythm coherence feedback system designed to facilitate acquisition and internalization of the emotional management skills taught in the program.

Major Findings: Primary Study

The primary study produced a number of important findings, which are summarized below.

Pre-Intervention Findings

Across the whole sample at baseline, before the TestEdge intervention, the primary study found that:

- 61% of all students reported being affected by test anxiety, with 26% experiencing high levels of test anxiety often or most of the time.
- Twice as many females experienced high levels of test anxiety, as compared to males.
- There is a strong negative relationship between test anxiety and test performance; students with high levels of

test anxiety scored, on average, 15 points lower on standardized tests in both Mathematics and English-Language Arts than students with low test anxiety (Figure 1).

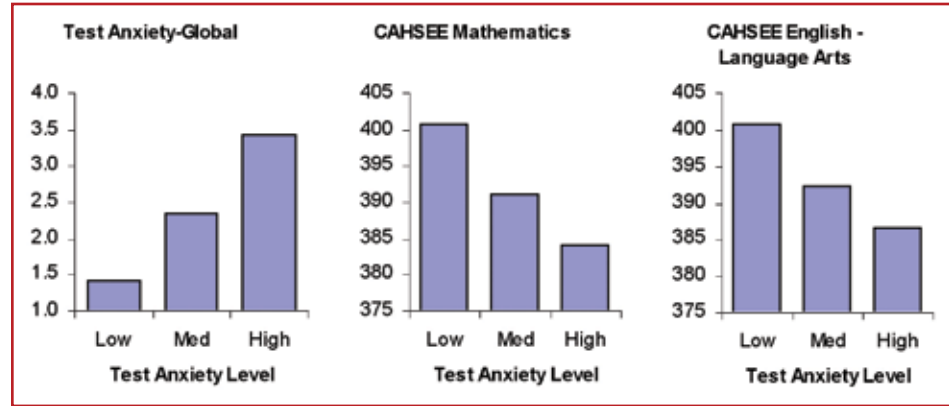


Figure 1. High School Exit Examination Scores by Baseline Test Anxiety Level

Baseline test anxiety, measured by the Test Anxiety Inventory (TAI)-Global Scale score, and midterm California High School Exit Examination (CAHSEE) scores in English-Language Arts and Mathematics have been classified into three approximately equal-sized groupings (tertiles) of students with low, medium, and high test anxiety scores. A strong, statistically significant ($p < 0.001$) negative relationship is clearly apparent between mean level of test anxiety and mean performance on the standardized tests: as test anxiety increases, test performance decreases.

● Five common factors were found in regression analysis models to explain student test performance on the CAHSEE and CST: Test Anxiety-Worry, Test Anxiety-Emotionality, Feelings about School, Life Preparedness, and Educational Plans. For both tests the regression models explained about 20–24% of the variance in student test performance; test anxiety accounted for about half of the explained variance.

● Multiple regression analysis found that measures of Affective Mood explained almost twice the variance in student test performance on both the CST-ELA and CAHSEE-ELA as items from the Test Anxiety scale (23% versus ~13%, respectively). Positive feelings and prosocial behaviors had a positive effect on test performance, while strongly negative feelings and antisocial behaviors had a negative impact.²

Taken as a whole, these findings are sobering and justify the concern that test anxiety may significantly jeopardize assessment validity and therefore may constitute a major source of test bias.

Post-Intervention Findings

After the TestEdge program had been delivered to the students in the experimental school, we found strong, consistent evidence of a positive effect of the intervention on these students when compared to those in the control school:

- There was a significant reduction in the mean level of test anxiety. Of those students at the intervention school who had reported being affected by test anxiety at the beginning of the study, 75% had reduced levels of test anxiety by the end of the study.
- This reduction in mean test anxiety was also evident for more than three-quarters of all classrooms, and it was observed throughout the academic ability spectrum—from high test-performing classes to low.
- The reduction in test anxiety was associated with the following improvements in socioemotional measures (Figure 2):
 - A reduction in Negative Affect (feelings of stress, anger, disappointment, sadness, depression, and loneliness);
 - A reduction in Emotional Discord, reflecting increased emotional awareness and improved emotional management;
 - A reduction in Interactional Difficulty, reflecting increased empathy and improved relations with others;

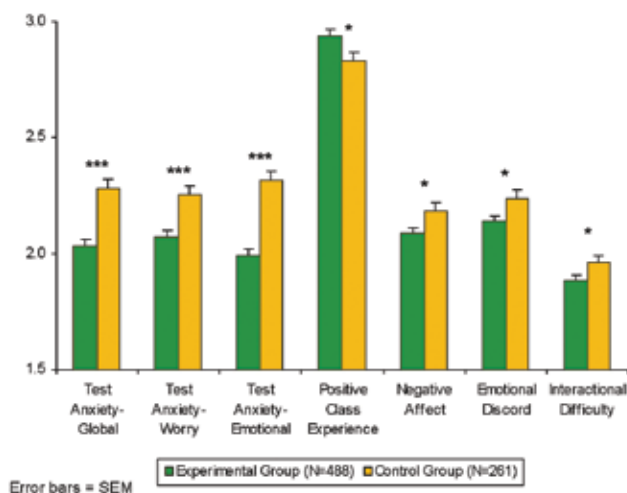


Figure 2. Pre-Post Changes in Test Anxiety and Socioemotional Measures Comparing Intervention and Control Schools

Results of an ANCOVA of pre-post-intervention changes in measures of test anxiety (Global scale, Worry component, and Emotionality component) and socioemotional scales (Positive Class

Experience, Negative Affect, Emotional Discord, and Interactional Difficulty) showing significant differences between the intervention and control schools. * $p < 0.05$, *** $p < 0.001$.

- An increase in Positive Class Experience, reflecting perception of increased enjoyment and learning in class, positive feelings toward classmates, and teacher care.
- In four matched-group comparisons (involving sub-samples of 50 to 129 students) there was a significant increase in test performance in the experimental group over the control group, ranging on average from 10 to 25 points.
- In two of these matched-group comparisons, this significant increase in test performance was associated with a significant decrease in test anxiety in the experimental group (Figure 3).

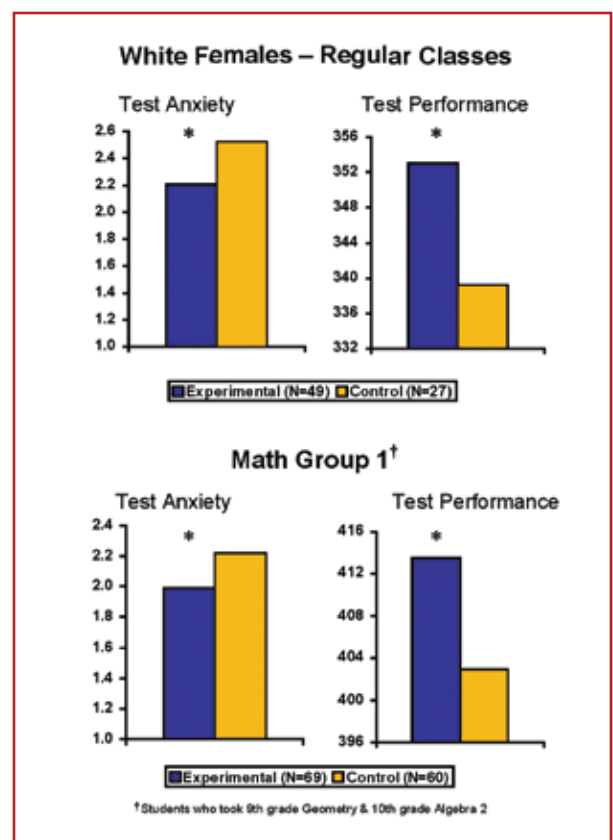


Figure 3. Changes in Test Anxiety and Test Performance in Matched-Group Comparisons

ANCOVA results for two sub-samples from the intervention and control schools matched on sociodemographic factors (White Females in average academic level classes) and 9th grade Math test performance (Math Group 1), respectively. For these matched-group comparisons, significant reductions in test anxiety in conjunction with significant improvements in test performance (California Standards Test – English-Language Arts) were observed in the experimental group as compared to the control group. * $p < 0.05$.

Physiological Study Findings

Results from the electrophysiological study provided compelling evidence for the hypothesis of a causal link between increased psychophysiological coherence and the cognitive functions central to learning and test-taking. In a controlled experiment simulating a stressful testing situation, a random sample of students (N = 136) completed a computerized version of the Stroop color-word conflict test (a standard protocol used to induce psychological stress), while continuous heart rate variability recordings were gathered. For the pre-intervention administration of the experiment, students were instructed to employ whatever methods they typically used when preparing to perform a challenging test or activity. In the post-intervention session, students in the intervention group were instructed to use one of the TestEdge coherence-building techniques to ready themselves for the test, while the control group students again used their own methods.

The data suggest that when students self-manage their stress using coherence-building methods, it enables them to achieve both a significant reduction in test-related anxiety and a corresponding improvement in standardized test scores. Specifically, results from the post-intervention physiological experiment demonstrated that:

- Students in the experimental group had acquired the ability to self-activate the coherent state prior to taking an important test (see Figure 4).

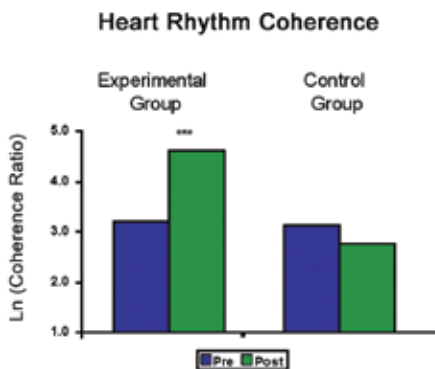


Figure 4. Heart Rhythm Coherence While Preparing for a Stressful Test

These data are from the electrophysiological sub-study—a controlled experiment involving a random stratified sample of students from the intervention and control schools (N=50 and 48, respectively). In this experiment, students were administered the Stroop stress test while heart rate variability was continuously recorded. These graphs quantify heart rhythm coherence—the key marker of the psychophysiological coherence state—during the stress preparation phase of the protocol.



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Data are shown from recordings collected before and after the TestEdge intervention. The experimental group demonstrated a significant increase in heart rhythm coherence in the post-intervention recording, when they used one of the TestEdge tools to prepare for the stressful test, as compared to the control group, who used their own stress preparation techniques. *** $p < 0.001$.

- This ability to self-activate coherence was associated with significant reductions in test anxiety and corresponding improvements in measures of emotional disposition.

- Students in the experimental group also exhibited increased heart rate variability and heart rhythm coherence *during the resting baseline period in the post-intervention experiment—even without* conscious use of the TestEdge technologies. This suggests that through their consistent use of the TestEdge techniques over the study period, these students had instantiated a healthier, more harmonious, and more adaptive pattern of psychophysiological functioning as a new baseline or norm.

- In a sub-sample of students matched on baseline test scores, the capacity to self-activate coherence was associated with a reduction in test anxiety as well as an improvement in test scores in the experimental group (see Figure 5).

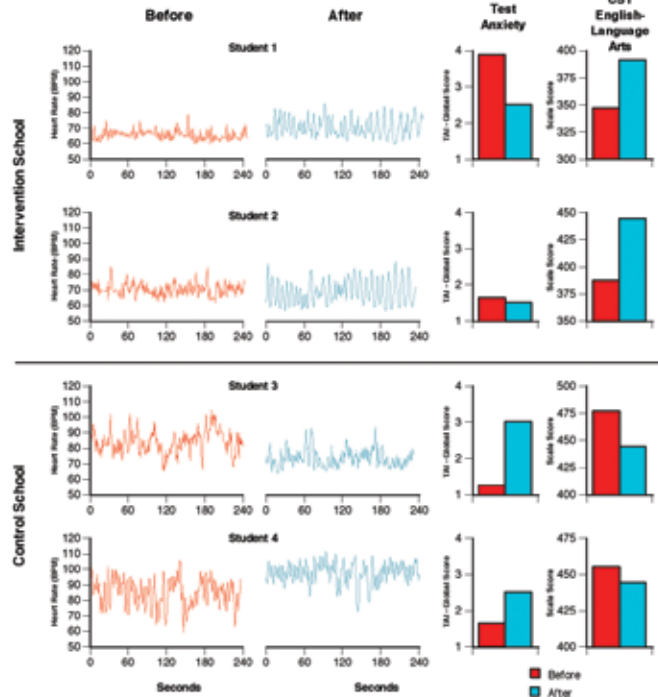


Figure 5. Typical Heart Rate Variability Patterns in Four Students Preparing for a Stressful Test

Heart rate variability (HRV) recordings from the electrophysiological study, showing four students' heart rhythm patterns while they prepared for themselves for the Stroop stress test,

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both before and after the TestEdge intervention. Pre- and post-intervention test anxiety level (TAI-Global Scale score) and the California Standards Test (CST)–English Language Arts test score for each student are also shown. For the two students in the intervention school, the recordings show a shift from an erratic, irregular heart rhythm pattern (left-hand side) before the intervention, to a sustained sine-wave-like pattern (increased heart rhythm coherence), indicative of the coherence state, after the intervention. By contrast, both the pre and post HRV recordings for the students in the control school signify an ongoing incoherent psychophysiological state.

Findings from the Study of Student Drawings

A window into how students see and feel about themselves while taking an important test was provided by an assessment of student drawings collected as a part of the Student Opinion Survey questionnaire administered in the primary study. Altogether, a total of 1,581 drawings were collected (830 pre- and 751 post-intervention). From the analysis of a random sample of 95 pre-intervention drawings³, it was found that:



- The overwhelming majority of student drawings conveyed strongly negative feelings and emotions.
- The drawings contained very few depictions of adults which, almost without exception, were negative.

From an analysis of the pre-post pairs of drawings, we identified the following patterns of post-intervention change along three dimensions in sub-samples of students (N = 109) drawn from the intervention school:

- Movement from a negative to a positive self-concept.
- Movement from negative to positive feelings and cognitions.
- Movement from negative to positive perceptions of self-control and success.

In contrast to these positive patterns of change, very few instances of positive pre-post change were observed in the student drawings from comparable sub-samples (N = 54) in the control school.

Qualitative Findings

To supplement the quantitative data, the primary study also gathered observations of classroom interactions in the two schools and conducted structured interviews with teachers.



Classroom Observations

An observational protocol was developed for systematic data collection from three periods of passive observation of the socioemotional environment and interaction patterns in classrooms before, during, and after the TestEdge intervention. The observational findings are broadly consistent with the findings from the quantitative analysis. More specifically, results from a study⁴ of pre-post-intervention classroom observations comparing the two schools showed that:

- More positive changes were observed in the classrooms of the experimental school while more negative changes were observed in the control school.
- Students at the experimental school exhibited reduced levels of fear, frustration, and impulsivity. They also displayed increased engagement in class activities, emotional bonding, humor, persistence, and empathetic listening and understanding.

Teacher Interviews

A number of important findings emerged from the teacher interviews:

- Most teachers acknowledged that their students came to school emotionally unprepared to learn.
- Most teachers felt that their educational training did not equip them with the requisite skills to effectively manage their own stress or to help their students to do so.
- Most teachers were supportive of integrating emotional management instruction into educational curricula.
- Most teachers reported experiencing personal benefits as well as positive changes in their students' behavior as a result of the intervention program.

Major Findings: Secondary Study

Evaluation of the implementation case studies of the TestEdge program, conducted in selected classrooms at various grade levels across different states, produced a number of notable results.

- Corroborating the findings from the primary study, interviews with teachers revealed that:
 - The lack of emotional self-management education for students was seen as a significant obstacle to learning and academic performance
 - Few felt they possessed the requisite emotional management skills to effectively manage stress or to teach their students how to do so
 - Most felt the program provided substantial benefits in both their professional and personal lives
- In relation to the program's impact on their students, the teachers:
 - Described positive changes in students' attitudes, behaviors, test anxiety and academic performance
 - Felt that the tools and skills would have a positive impact on students' future socioemotional and academic development
- In general, the program's implementation was more successful when:
 - There were several teachers at the same grade level teaching the course
 - Teachers were able to internalize the use of the tools in their own lives
- In general, major challenges to successful program implementation were:
 - Inadequate class time
 - Logistical, coordination, and communication problems encountered with school administration
 - Securing the support of the principal and other key school administrators to foster teacher commitment

Elementary School Case Study

An exemplary case of a highly successful implementation of the TestEdge program was provided by an in-depth study conducted at the third grade level in a Southern



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California elementary school. Several notable findings emerged from the study:⁵

- Large increases in state-mandated test scores were observed, which far exceeded academic targets for the year. Student proficiency grew from 26% to 47% in English-Language Arts and from 60% to 71% in Mathematics.
- Corresponding emotional and behavioral improvements among students in the classrooms were also observed.
- Success of the implementation was largely due to the enthusiastic support provided by the school's principal and key teachers and administrators.



¹ M. H. Immordino-Yang & A. Damasio. "We Feel, Therefore We Learn: The Relevance of Affective and Social Neuroscience to Education." *Mind, Brain, and Education*, 2007, 1(1): 3–10.

² K. Hartnett-Edwards. *The Social Psychology and Physiology of Reading/Language Arts*. Doctoral Dissertation, Faculty of Education, Claremont Graduate University, Claremont, CA, 2006.

³ L. Schroeder, L. Arguelles, & S. Bouman. "Drawing to Survive: A Holistic Assessment of Student Images of the High-Stakes Testing Experience." Paper presented at the American Educational Research Association Annual Meeting, San Francisco, CA, 2006.

⁴ T. Hollingsworth. "Observational Changes in Tenth Grade Classroom Environments: Qualitative Measures of TestEdge Intervention on Test Anxiety." Unpublished paper, Claremont Graduate University, Claremont, CA, 2006.

⁵ J. Lagozzino. "Background Information and Observations on the Implementation of the TestEdge Curriculum in Third Grade at [Southern California] Elementary." Unpublished paper, Claremont Graduate University, Claremont, CA, 2006.

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The more educators come to understand the nature of the relationship between emotion and cognition, the better they may be able to leverage this relationship in the design of learning environments.

—Immordino-Yang & Damasio (2007: 3)¹

Conclusion

Overall, the preponderance of evidence from this rich combination of physiological, quantitative, and qualitative data, indicates that the TestEdge program led to a number of important successes. There is good reason to believe that the program produced substantial physiological, psychological, academic, and social benefits for the participating students.

It is our hope that the results of this research will have an impact on policies regarding the importance of integrating stress and emotional self-management education into school curricula for students of all ages. By introducing and sustaining appropriate programs and strategies, it should be possible to significantly reduce the stress and anxiety that impede student performance, undermine teacher-student relationships, and cause physiological and emotional harm. Such programs have the promise of increasing the effectiveness of our educational system and, in the long-term, boosting the academic standing of the United States in the international community.



Endorsements

"I was thrilled to read HeartMath's comprehensive report on the results of the TestEdge National Demonstration Study. The study is superb...(and) yielded an impressive body of cross-corroborating evidence documenting the effectiveness of the TestEdge program in reducing student test anxiety and improving test performance. Of particular import is the physiological evidence indicating that students in the program had established a new set point of emotional stability—a requisite for sustained behavioral change. The study is an exemplar of how social science experiments in open field research settings ought to be done."

—KARL H. PRIBRAM, M.D., PH.D. (Hon. Multi.)
Neuropsychologist; Author – *Brain and Perception* and *Languages of the Brain*; Professor Emeritus, Stanford University; Distinguished Research Professor, Georgetown University

"The detailed information presented in this report ...provides impressive evidence of the effectiveness of the TestEdge program. For students who were trained to use the TestEdge program to manage their stress, this resulted in significant reductions in the Test Anxiety Inventory scores and corresponding improvement in scores on standard measures of academic performance. I was especially impressed with the careful statistical analyses of the data,...(which) provide impressive evidence that the TestEdge program is an effective intervention for reducing test anxiety and facilitating academic performance."

—CHARLES D. SPIELBERGER, PH.D., ABPP
Psychologist; Author – *Understanding Stress and Anxiety*, *State-Trait Anxiety Inventory*, and *Test Anxiety Inventory*; Distinguished Research Professor of Psychology and Director, Center for Research in Behavioral Medicine and Health Psychology, University of South Florida

"As an author primarily concerned with the development of intelligence in children, whose eight books on that general theme have been published and translated into many languages,...I predict that within a decade nothing less than a true revolution in child development, rearing, and education will be brought about by HeartMath's TestEdge research.

Of all the HeartMath reports, this one holds the greatest promise. It is a goldmine of information, research, and insight....That the biological basis for learning lies in the emotional structures of brain and heart, not in intellectual schema and enforced modifications of behavior, is literally the liberation of childhood and the society as a whole. All I can do is applaud, with a grateful heart."

—JOSEPH CHILTON PEARCE
Specialist in early child development; Author – *Magical Child*, *Evolution's End*, and *The Biology of Transcendence*