ABSTRACT

Rationale. NAEP is a critical source of information about the academic achievement of our nation's children. Analysis of NAEP datasets consistently has revealed substantial gaps in achievement between males and females, between racial-ethnic groups, and between groups of varying social status. Conclusive explanations for these persistent associations remain elusive. Moreover, differences reported for these populations can be misleading because individuals in the same subpopulations (*e.g.*, males) are quite different otherwise (*e.g.*, minority status, home environments).

There is ample theoretical and empirical evidence that such insight can be obtained by conceptualizing demographic differences in terms of social contexts, or collections of variables, that alter the psychological significance and social demands of life events, and affect academic risk and resilience (Gore & Eckenrode, 1994). The proposed research integrates psychological and educational perspectives to scrutinize the compensatory and interactive effects of four classes of protective factors, namely, attitudes and beliefs about science, home environment, school climate, and the quality of students' learning experiences, on science achievement in different social contexts. Examining how protective factors mediate academic risk at different grade levels can lead to improved use of NAEP science proficiency data for stimulating discussion about the relative effectiveness of educational interventions for students at risk.

Design and Analysis. The proposed analysis will be based on data collected from national samples of 4^{th}, 8^{th}, and 12^{th} grade students as part of the NAEP 1996 science main assessment. Estimation of the effects of protective factors on science achievement is complicated by three methodological challenges posed by the NAEP data, namely, taking account of the multi-stage cluster sampling design; accounting for unequal selection probabilities associated with

stratification and over-sampling of certain subpopulations; and handling measurement error associated with the matrix sampling scheme. If these issues are not handled appropriately, results of policy analyses could be misleading. The hierarchical statistical model we plan to apply is appropriate for estimating the direct and indirect effects of social context, protective factors, and their interactions on science achievement (Bryk & Raudenbush, 1992). The analysis promises to provide reliable estimates of the sources of achievement gaps and conditions that contribute to resilience of individuals with high statistical probabilities of academic risk.

Significance/Intended Outcomes. The proposed analysis will compare differences in the impacts of protective factors in social contexts. Analyzing protective factors in different social contexts may help explain why some groups of individuals statistically are more vulnerable than others, and why some individuals at risk are more resilient than others. Although causal inference based on these findings is unjustified, the comparisons will produce suggestive results of interest to policy makers and educators and will stimulate discussion about the significance of social context and sources of variation for students at risk and plausible mechanisms for school improvement.

APPLICATION NARRATIVE

TABLE OF CONTENTS

PROJECT DESIGN

PART 1: CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

This application responds to Invitational Priority1. The proposed project will apply an approach to analysis and reporting of NAEP 1996 science achievement data from grades 4, 8, and 12 that will assist policy makers and educators who make decisions affecting curriculum and instruction. This project will examine the extent to which academic risk and resilience are affected by psychological and environmental protective factors. Our broad goals are (1) to identify the nature and extent of protective mechanisms that moderate academic vulnerability and resilience; and (2) to compare the direct and indirect effects of school curricular and instructional policies on achievement of groups of students with different probabilities of academic risk. The analyses are expected to improve interpretation of the Nation's Report Card and stimulate discussion about the relative effectiveness of instructional interventions aimed at raising achievement for individuals in different social contexts.

Academic Risk and Resilience.

The study of students at risk is a major topic of education policy and discussion. Much research has focused on describing conditions associated with statistical risk of undesirable outcomes among individuals who are members of groups characterized by problems such as poverty and social disadvantage. When groups of students with similar backgrounds are compared, students from families with high socioeconomic status (SES) outperform students from low SES families; Asian and white students have higher achievement than black or Hispanic students; and males do better than females (Coleman, et al., 1966; Gibbons, 1992; Hilton & Lee, 1988; Hoffer, Rasinski, & Moore, 1995; Madigan, 1997; Mason & Kahle, 1989). No single explanation is sufficient to account for observed average differences in science achievement. Even more of a mystery is why some resilient students “beat the odds” and demonstrate high achievement despite statistical predictions to the contrary.

One of the most commonly investigated risk factors is low SES. Low achievement is attributed to the paucity of resources available to poor people resulting from low level of parental education, low status parental occupation, large family size, and absence of one parent (Luthar, 1991). Empirical findings show that risk factors have a reciprocal relationship with one's social class status (Garmezy, Masten, & Tellegen, 1984; Masten, Garmezy, Tellegen, Pellegrini, Larkin, & Larsen, 1988). Higher SES is associated with greater social support, fewer school and behavior problems, and greater social competence. Reviews of resilience and vulnerability to adverse outcomes of childhood poverty have emphasized the necessity of exploring the means by which such processes occur (Garmezy, 1991; Rutter, 1994). This exploration has yielded strong empirical evidence that average or above-average intellectual ability contributes to resilience among students from low SES families (Garmezy, 1985; Herrenkohl, Herrenkohl, & Egoff, 1994; Luthar, 1991; Madge & Tizard, 1981; Radke-Yarrow & Sherman, 1990; Rutter, 1979; Werner & Smith, 1982). What is uncertain is how the protective effects of intelligence interact with the gender, racial-ethnic status, or both, to moderate resilience of poor children.

Gender has been implicated as an important influence in explaining resilience (Rutter, 1979; Werner & Smith, 1982). The implications for gender differences in achievement are provocative, particularly since they are accompanied by a considerable body of theoretical and empirical evidence documenting the psychological impact of gender differences in self-esteem on normal development (Gore & Eckenrode, 1994). Developmental research studies show that females’ sense of negative emotion is greater than that of males and is tied to concerns about relationships (Czikszentmihallyi & Larson, 1984; Larson & Asmussen, 1991). Bush and

Simmons (1987) suggest that early adolescent girls experience higher levels of stress as a result of transition to high school because of the greater dependence of their self-esteem on expectations of others and establishing personal social ties. Gender-related differences in self-esteem could influence the beliefs of females about their ability to do well in science and their willingness to take advantage of educational opportunities.

One of the most controversial findings in studies of adolescent achievement is an association with ethnicity. Although there is considerable consensus that ethnic differences in school performance are genuine, there is less agreement as to their causes (Lynn, 1977; Mickelson, 1990; Mordkowitz & Ginsburg, 1987; Ogbu, 1991; Ogbu, 1992; Sue & Okazaki, 1990). One popular theory is that blacks and Hispanics perceive the opportunity structure differently than whites or Asians (Ogbu, 1978). Parallel studies on children in highly stressed urban environments found that expectations and beliefs operated as protective factors that mediated the resilience or vulnerability of affected individuals (Clausen, 1991; Cowen, Work, & Wyman, 1992; Israelashvili, 1997; Wyman, Cowen, Work, & Kerley, 1993). Academic resilience of minority students may be particularly sensitive to the opportunities structured by schools through policies that provide stimulating intellectual environments and maintain disciplinary climates essential for reducing exposure to stressful situations that disaffect learning.

While isolated risk indicators such as socioeconomic status, racial-ethnic status, and gender may be highly predictive, they should not be interpreted as conclusive. Risk is the heightened probability of an undesirable outcome for a population, not for an individual (Bender & Losel, 1997; Garmezy & Masten, 1986). This subtle but significant distinction means that *individuals* are not at risk for low science achievement because they are poor, female, or minorities. Rather, individuals with low SES, minorities, and females are part of highly variable risk populations. Overlooking this distinction ignores substantial within-group heterogeneity that accounts for most of the variance in science achievement. Characterizing individuals on the basis of group achievement fails to reveal the qualities or factors that predispose resilient individuals to overcome the stereotypes and stigmas predicted by group affiliation (Catterall, 1998; Nettles & Pleck, 1994; Richters & Weintraub, 1990). Theoretical guidance for investigations about why, on average, groups of students consistently perform more poorly in science, and why some individuals in these groups beat the odds and perform quite well, is found in a strand of research in developmental psychology and psychopathology dealing with risk and resilience.

Social Context.

Garmezy, Masten, and Tellegen (1984) define psychological resilience as the manifestation of competence despite exposure to risk mechanisms that lead to deleterious outcomes. Resilience is not a rare occurrence. As many as one-quarter to one-half of children exposed to severe stress and adversities develop into competent and caring adults and do not succumb to psychopathology (Reynolds, 1998; Rutter, 1985; Werner, 1989). Growing awareness of the ubiquity of resilience was coupled with recognition that simple models of risk were inadequate to explain how the interplay of complex developmental processes and protective mechanisms with risk factors fostered resilience in social contexts (Masten, Garmezy, Tellegen, Pellegrini, Larkin, & Larsen, 1988; Rutter, 1987; Seifer & Sameroff, 1987). There is ample theoretical and empirical evidence that demographic differences should be conceptualized as social contexts, or collections of variables, that alter the psychological significance and social demands of life events and affect subsequent relationships between risk and resilience (Gore & Eckenrode, 1994).

Most of the research on psychosocial risk factors has provided data on how to identify risk variables. However, these epidemiological models are limited in that outcomes are easily attributed to risk-related or compensatory factors even though the nature and extent of the mechanisms that account for their influence remains unknown (Compas, Howell, Phares, Williams & Giunta, 1989; Masten & Garmezy, 1985; Richters & Weintraub, 1990; Rutter, 1994). Over the last ten years the research agenda in developmental psychology has embraced models that focus on how protective effects interact with social context to moderate the influence of risk factors (Blocker & Copeland, 1994; Floyd, 1996; Garmezy, 1991; Grossman, Beinashowitz, Anderson, Sarurai, Finnin, & Flaherty, 1992; Israelashvili, 1997; Jackson, Born, & Jacob, 1997; Luthar, 1991; Rutter, 1987; Radke-Yarrow & Sherman, 1990; Werner, 1989; Werner & Smith, 1992). An emerging focus of this research strand has been on resilient individuals who defy expectations by developing normally and coping with their lives effectively.

Protective Factors.

Garmezy (1983, 1985) identified three broad sets of protective factors that contribute to resilience and moderate predictions of vulnerability based on an individual's risk status: (1) personality attributes such as attitudes and beliefs; (2) home environments; and (3) the quality of external support systems such as schools. There is substantial empirical evidence that resilience of children is patterned, at least in part, by these variables (Brooks, 1994; Floyd, 1996; Garmezy, 1983, 1991; Gonzalez & Padilla, 1997; Luthar & Zigler, 1991; Rak & Patterson, 1996; Rutter, 1987). While Garmezy did not focus specifically on educational outcomes, his assessment resonates with results from educational research (Catterall, 1998; Coleman & Hoffer, 1987; Freiberg, 1993; Gonzalez & Padilla, 1997; Lee, Chen, & Smerdon, 1996; Peng & Wright, 1994;

Rak & Patterson, 1996; van Welzenis, 1997; Wang & Gordon, 1994). Such evidence provides a starting place for understanding how students' attitudes and beliefs, home learning environments, and school qualities could mediate risk mechanisms and foster academic resilience.

Positive Attitudes and Beliefs. Some educators argue that fostering positive attitudes about science is one of the most desirable outcomes of science education (Carey & Shavelson, 1988; George & Kaplan, 1998; Greenfield, 1996; Raizen & Jones, 1985). Positive attitudes have long been believed to increase formal and informal science learning after the direct influence of the teacher has ended (Mager, 1968). More recent studies provide evidence that positive attitudes foster science achievement and career interest by increasing the likelihood that students will enroll in advanced science courses and engage in future activities associated with life-long learning of science (Carey & Shavelson, 1988; Mason & Kahle, 1989; Norwich & Duncan, 1990).

Published results from the NAEP 1996 science assessment (O'Sulllivan & Weiss, 1999) show that attitudes toward science vary significantly for males and females and for members of different racial-ethnic groups, particularly by 12th grade. Women and minorities, two groups at higher risk for low achievement, are more likely to have negative attitudes about the significance of science in every day life and poor self-concepts regarding their ability to do well in science. Research suggests that the relatively poor academic performance of females and minorities stems, at least in part, from their more negative attitudes and beliefs about science (Clewell, Anderson, & Thorpe, 1992; Skolnick, Langbort, & Day, 1982).

Home Environments. One of the oldest and most persistent explanations for achievement differences is that educational opportunities provided at home affect students' readiness to learn (Coleman, et al., 1966). While hundreds of studies attest to associations between home environments and achievement throughout a child's school career, less attention has been paid to significant systematic variability in achievement among students from families with access to similar opportunities. What is not clear is how access to opportunities such as a rich collection of literacy-based materials in the home interacts with other social context factors to influence learning readiness and subsequent achievement. The proposed research examines the extent to which home learning opportunities matter for students at different grade levels, and whether, on average, students with different statistical probabilities of risk benefit equally from these opportunities.

School Environments. Two school-level protective effects are school climate and the instructional program. The effects of these protective factors have potentially important implications for the proposed analysis because they suggest ways in which academic outcomes can be mediated by school policies and practices.

School Climate. An orderly disciplinary climate is a pre-condition for academic engagement and a measure of school quality (Phillips, 1997). Reliable indicators of school climate include attendance, truancy, cutting class, lateness, damaging property, and fighting (Raudenbush, Fotiu, & Cheong, 1998). Poor disciplinary climates have been shown to increase the vulnerability of students at risk for low achievement and contribute to inequitable distribution of achievement within schools (Bryk & Thum, 1989; Lee, Chen, & Smerdon, 1996). Favorable school climate may be especially influential for disadvantaged schools that suffer already from an academic program compromised by inadequate facilities and equipment and lack of money to purchase consumable supplies necessary for advanced scientific inquiry.

Learning Experiences. The National Science Education Standards (National Research Council, 1996) include specific guidelines describing what science instruction should look like in elementary and secondary classrooms. The Standards describe science learning experiences where students have ample opportunities to (1) conduct hands-on inquiry in their classrooms; (2) work together in small, cooperative groups, (3) communicate understandings orally and in writing; and (4) relate science to everyday life and experiences beyond the classroom. There is substantial empirical and theoretical evidence that these kinds of learning experiences are a starting point for personal construction of meaning and can lead to higher achievement of all students (Anderson, 1998; Burkam, Lee, & Smerdon, 1997; Carey, 1985; Carmichael, et al., 1990; Ertepinar & Geben, 1996; Freedman, 1997; Glasson, 1989; Lee & Burkam, 1996; Lee, Chen, & Smerdon, 1996; Odubunmi & Balogun, 1991; Piaget, 1970; Stohr-Hunt, 1996; von Glaserfeld, 1984, 1987; Von Secker & Lissitz, 1999). One question that has not been well explored is whether the "payoff" associated with specific instructional practices varies significantly for individuals with different probabilities of academic success.

One of the criticisms of the Standards is that, although they emphasize the importance of promoting science achievement for all students regardless of demographic status, the proposed science education reforms do not directly address theoretical issues surrounding ethnic, socioeconomic, and gender equity (Rodriguez, 1997). And while there is some evidence that instructional emphases explain discrepancies in student achievement (McCauley, 1995; National Center for Education Statistics, 1992), there is no empirical evidence to support the viability and utility of proposed instructional reforms for creating more equitable opportunities for students nationwide (Donmoyer, 1995; Riechard, 1994). In general, evidence explaining how learning experiences interact with combinations of student background variables to influence science achievement is sparse.

Analyzing Protective Effects in Social Contexts.

Garmezy, Masten, and Tellegen (1984) proposed three regression-based models for making conceptual distinctions about the processes though which factors moderate the effects of life stress. The simplest of these, the compensatory model, gets its name because the impact of risk is compensated for, or counteracted by, protective effects. In the compensatory model, the direct effects of risk and protective mechanisms contribute additively in the prediction of competence. When a risk factor is held constant, competence covaries positively with the strength of the adaptive attributes. The less-frequently used challenge model takes its name from the idea that stress associated with a risk factor can enhance competence, provided the stress is not excessive. The possibility of a curvilinear relationship is tested by including a stress-inducing risk factor as a quadratic term in the regression equation. The protective factor model is a multiplicative one consistent with the theoretical definition of resilience proposed by Rutter (1987), in which protective mechanisms interact with risk factors to diminish or magnify their impact. When an interactive component is not statistically significant, the process mediating resilience is sufficiently explained by a compensatory model.

In the last 15 years there have been significant moves toward greater specification of the mediating mechanisms that emphasize the role of cognitive appraisal of life events, the social contexts in which they occur, and the mediating mechanisms involved in the risk processes associated with psychosocial experiences that carry an increased risk of psychopathology. Rutter (1987) and Masten and Garmezy (1985) have emphasized the methodological importance of testing for interaction effects in order to understand the specific protective mechanisms that underlie resilience. Identification of a statistically significant interaction is generally considered evidence of a moderating effect between stress and adjustment. However, finding these effects can be complicated by three methodological problems: the need for large sample sizes; the complexities of interpretation; and small effect sizes (Luthar & Zigler, 1991). The proposed research uses an analytic approach that overcomes these methodological complications. Findings will be useful for identifying interactive situational mechanisms that explain why some groups of individuals statistically are more vulnerable than others, and why some individuals within the same group are more resilient than others.

A caveat is in order with regard to interpretation of associations of protective factors with achievement. While the proposed approach is intended to encourage thinking about how processes and policies operating at the individual, home, and school levels of a student's educational environment mediate science achievement, causal inference based on results of the analysis is unjustified. These comparisons are designed to produce suggestive results that stimulate discussion about the sources of variation between and within social contexts, the relative effectiveness of interventions and policies for students at risk, and about plausible mechanisms for school improvement. They may inform policy, but should not prescribe it.

Objectives.

The purpose of the proposed project is to increase the interpretability of NAEP datasets and the objectivity with which policymakers can evaluate assessment data on science proficiency. Consistent findings reveal substantial gaps in achievement between racial-ethnic groups and between groups of varying social status. More information on the likely sources of these disparities is needed to translate such findings into possible implications for educational improvement. By subjecting these disparities to alternative explanations, the project aims to encourage a more informed debate. The proposed research combines a variety of perspectives to contribute to the development of a conceptual framework for relating student achievement to social context. A model that integrates psychological, sociological, and educational theories may shed more light on this important relationship than any one perspective alone. The proposed analysis will produce suggestive but not conclusive evidence of the links between protective factors and science proficiency.

Estimates of the influence of protective factors can provide better understanding of the roles of personal attributes, home learning environments, and school resources, practices, and policies for mediating academic risk in social contexts. It offers a way of mining rich, but as yet untapped, sources of information from NAEP datasets.

Our research questions are:

1. On average, are individuals from families of low SES equally likely to demonstrate academic resilience (*i.e.* have significantly higher than predicted science achievement) regardless of gender, racial-ethnic status, or both?
2. On average, are minority students more likely than majority students to demonstrate academic resilience when schools provide favorable disciplinary climates and stimulating intellectual environments?
3. On average, are males and females who are confident about their ability to do well in science equally likely to demonstrate academic resilience?
4. To what extent do psychological and environmental protective factors (*i.e.*, attitude and beliefs about science, home environment, and school quality) mediate academic resilience among at-risk students?
5. To what extent do differences in the associations of protective factors with science achievement vary across grades 4, 8, and 12?
6. What implications do these findings have for education policy?

PART 2: RESEARCH DESIGN

The proposed research design uses several methodological tools (*i.e.*, factor analysis, hierarchical linear modeling) to integrate, appropriately, perspectives from developmental psychology and science education. The approach links an extensive review of literature on risk and resilience with strands of research on science achievement and school effects. Results are expected to inform both fields by providing empirical support for theoretical explanations of the mediating effects of protective factors on science achievement.

Sample Characteristics.

The 1996 NAEP main assessment samples were selected using a complex multistage design involving students and schools from 94 selected geographic areas (PSUs) across the United Sates. The probability of students and schools being selected into the sample varied based on factors such as grade, subject, public and nonpublic status, and so on. However, within selected schools, all eligible students had an equal probability of inclusion. Students deemed ineligible by school authorities because of limited English proficiency or mental or functional disability were excluded.

The proposed research sample includes 4th, 8th, and 12th grade students from the 1996 NAEP main science assessment reporting sample for whom the following information is available: science achievement data (*i.e.*, plausible values for science), parent education, racial-ethnic status, and gender.

<u>Socioeconomic Status</u>. There is no direct measure of SES in the NAEP data. However a composite variable widely used in reporting NAEP data that measures parents' highest level of education is believed to be a reasonable proxy for SES. At each grade level, students were asked to indicate the extent of schooling for each of their parents. The information was combined into

one parental education reporting variable through the following process. If a student indicated the extent of education for only one parent, that was included in the data. If the student indicated the extent of education for both parents, the higher of the two levels was included in the data. In the proposed study, students will be assigned values from 1 to 4 depending on whether parents did not finish high school (students assigned a value of 1), graduated high school, had some education after high school, or graduated college (students assigned a value of 4).

Gender. In the proposed study, males will be assigned values of 1 and females will be assigned values of 0.

Minority Status. In the proposed research, students will be reclassified as either minority or majority students in order to maintain sufficient subgroup size. This means that black, Hispanic, and American Indian students will be assigned values of 1 (minority) and white and Asian-American students will be assigned values of 0 (majority). This approach is justified because of the similarities in the distribution of science achievement among groups of students assigned each value.

Instrumentation.

Science Achievement. Each student received an assessment booklet containing a set of general background questions, a set of subject-specific background questions, a set of questions about his or her motivation and familiarity with the assessment materials, and up to two sets, or "blocks," of cognitive questions that assessed the knowledge and skills outlined in the subject area framework. We will use the five plausible values generated from analysis of this data as the dependent variables in our hierarchical linear models.

Measures of Protective Factors. One goal of the proposed research is to investigate the mediating effects of protective factors in social contexts. Four classes of protective factors have been identified, namely attitudes and beliefs about science; home environment; school climate; and the quality of students' learning experiences.

Attitudes and Beliefs about Science. The NAEP student questionnaires for grades 4, 8, and 12 include eight identical items that measure students' attitudes about science and their beliefs about their ability to do well in science. Principal components analysis will be used to extract a composite that captures these attitudes and beliefs. The protective effects of positive attitudes and beliefs are expected to be particularly important in social contexts where students have a high probability of academic risk. A list of items used in the principal components analysis is presented in the Appendix in Table A1.

Home Environment. The NAEP dataset includes a number of student background items that reflect the educational environment of the home. One composite variable available in the student file, HOMEEN, is based on student responses to 4 questions about the availability of a newspaper, encyclopedia, magazines, and more than 25 books. This variable provides the most reliable indicator of the amount of literacy-based materials in the home and is used frequently in NAEP analysis as a predictor of the influence of home environments on achievement.

School Climate. In each participating school, the principal or other administrator completed a questionnaire that included items that asked about student absenteeism and tardiness, student and parent attitudes and support for achievement, teacher morale and attendance, and the extent to which student health and misbehavior, regard for school property, physical conflicts, gang activities, and drug use are problems at the school. We plan to use principal components analysis of 19 items from the school questionnaire to construct a composite that measures the school climate. A list of items considered for analysis is presented in the Appendix in Table A2.

Learning Experiences. Students at each grade answered a common set of questions that provided a profile of the extent to which their instructional experiences in science reflect the ideals set forth in the National Science Education Standards. Students reported the extent of their experiences with science inquiry in the classroom, the way they were taught (*e.g.*, reading textbooks, writing reports, working in groups); enrichment opportunities (*e.g.*, field trips, guest speakers, science fair projects, use of computer technology), and the amount of time they spent doing homework. We plan to use principal components analysis of aggregated student responses to construct a composite that measures the variety and quality of students' learning experiences at each school. A list of items considered for analysis is presented in the Appendix in Table A3.

Data Analysis Procedures.

Methodological challenges. Estimation of the effects of protective factors on science achievement is complicated by three methodological challenges posed by the NAEP data, namely, taking account of the multi-stage cluster sampling design; accounting for unequal selection probabilities associated with stratification and over-sampling of certain subpopulations; and handling measurement error associated with the matrix sampling scheme. If these issues are not handled appropriately, results of policy analyses could be misleading. The hierarchical statistical model we plan to apply for estimating the protective effects in social contexts accommodates all of these considerations.

Multi-stage Clustering. As the Nation's Report Card, NAEP must report accurate results for populations of students and subgroups of these populations (*e.g*., minority students or students attending nonpublic schools). To ensure accurate results, the relatively small samples of students selected for the NAEP assessments must be truly representative of the entire student population. Students were selected as part of a two-stage cluster sample (students within schools) with stratification at the first stage. Schools were initially stratified on the basis of urbanicity, minority concentration, size, and area income, and then schools within each stratum were selected at random. Students were selected at random within schools.

One computationally efficient and appropriate analytic method for handling this design is a two-level hierarchical linear model (HLM) in which students are level-one observations, schools are level-two observations, and each student's data is weighted inversely proportional to that student's probability of selection given the stratification. The HLM statistical program was specifically modified to make datasets such as NAEP more accessible to researchers (Bryk, Raudenbush, & Congdon, 1996). HLM resolves the problem of aggregation bias and imprecision inherent in analysis of multilevel data (Bock, 1989; Bryk & Raudenbush, 1987, 1992; Burstein, 1980; Burstein, Linn, & Capell, 1978; Goldstein, 1987). Over the last 15 years HLM has become widely used for policy analysis and evaluation of school effectiveness (Aitkin & Longford, 1986; Arnold, 1992; Bryk & Raudenbush, 1989; Gamoran, 1996; Gamoran, Porter, Smithson, & White, 1997; Lee & Bryk, 1989; Lee, Chen, & Smerdon, 1996; Phillips, 1997; Raudenbush & Bryk, 1986, 1989; Raudenbush & Willms, 1991, 1995; Raudenbush, Rowen, & Kang, 1991; dozens of others).

Weighting. Estimates of population and subpopulation characteristics in NAEP reports are derived using sample weights. Deliberate oversampling of certain populations (*e.g.*, private schools and public schools with moderate or high enrollments of black or Hispanic students) enhances the reliability of estimates for the oversampled subgroups but produces a sample containing proportionately more members of these subgroups than are in the population. In addition, nonresponse on the parts of schools and students results in a final sample that is unrepresentative of the number and types of students that would be found in a target population.

NAEP assigns weights to each assessed student and school to account for the unequal probabilities of selection and to adjust for nonresponse. The HLM program used in this analysis allows the researcher to weight level-one and level-two data simultaneously by the appropriate student and school weights provided in the NAEP dataset (ORIGWT and SCHWT, respectively). Johnson, Qian, Wallace, and Rust (1999) provide a technical description of the weighting procedures used in the 1996 NAEP assessment.

Matrix sampling plan. One of the challenges of working with NAEP data is to provide for the special character of the outcome variables used to assess achievement. Because of limitations on the amount of test time available and considerations of statistical efficiency, students are observed on only a subset of relevant items. The matrix sampling scheme of NAEP insures that no student will have a typical outcome score. NAEP uses scaling models to summarize student performance and account for substantial amounts of missing data. Multiple imputation procedures are used to produce five plausible values based on random draws from the posterior distribution of each student's true outcome given the subset of items observed on that student. Plausible values estimate students' true proficiency given the item responses and other characteristics of the students.

Current versions of the HLM program compute separate analyses for each of the five plausible values and then synthesize the results via an adaptation of Rubin's (1987) recommended approach to the analysis of multiply imputed data. This procedure takes into account the extra uncertainty that arises because multiple plausible values rather than a single observed outcome were available (Mislevy, Johnson, & Muraki, 1992). This type of analysis has been subject to expert review at NCES over the last ten years and has become widely used for analysis of NAEP data.

In summary, the methodological challenges of estimating the effects of protective factors can be handled by using a two-level hierarchical linear model that represents the random variation at each level via variance components and therefore appropriately adjusts standard errors for cluster effects, that is, effects shared by students within a school. This approach obtains unbiased parameter estimates by weighting observations according to the unequal probabilities of selection in the several strata. The modification of HLM computation procedures accounts for the uncertainty associated with the multiple plausible values yielded in the NAEP proficiency analysis.

HLM Analysis. The proposed analysis uses a two-level hierarchical linear model (HLM) to examine the relative contributions of protective factors in different social contexts. Because HLM calculates both intercept and slope heterogeneity, estimates of associations of protective effects with science achievement will include analysis of the direct and indirect effects of individual, home, and school characteristics. A detailed explanation of the data analysis methods used by HLM is available in Bryk and Raudenbush (1992).

Fully Unconditional Model. We plan to use a series of two-level hierarchical linear models to compare outcomes of students at grades 4, 8, and 12. At each grade level, the dependent variables will be 5 plausible values for science achievement. In the fully unconditional model, a series of regression equations (one per school) predicts achievement as a function of mean school achievement. The result can be interpreted essentially the same way as a one-way analysis of variance with random effects. The level-one equation for the fully unconditional model estimating achievement, Y_{ij}, of person *i* in school *j* has the form: $Y_{ij} = \beta_{0j} + r_{ij}$. β_{0j} represents the mean achievement of school *j* and r_{ij} is the deviation of the achievement of person *i* from mean achievement of school *j*. R_{ij} is assumed to be normally distributed with mean 0 and variance σ^2. The level-two equation for the random intercept, β_{0j}, has the form $\beta_{0j} = \gamma_{00} + \mu_{0j}$. Here, γ_{00} equals the grand mean achievement for the population of schools and μ_{0j} is the deviation of the mean of school *j* from grand mean achievement. The values of μ_{0j} are assumed to be normally distributed with mean 0 and variance t_{00}. The expanded equation for the unconditional model is:

$$Y_{ij} = \gamma_{00} + \mu_{0j} + r_{ij}.$$

A fully unconditional two-level HLM partitions variance in science achievement into that part that is unique to schools (t_{00}) and the pooled within-school residual (s^2). These estimates of the variance components will be used to calculate the intraclass correlation (ICC), an index that measures the degree to which students who attend the same school are more like each other than they are like students at other schools. The intraclass correlation (?) is given by the formula: ? = $t_{00}/(t_{00} + s^2)$. Using HLM to control for cluster effects is justified even when ICCs are as low as 0.02 (Kreft & De Leeuw, 1998).

Within-School Model. In the within-school model, the *j* regression equations predicting individual achievement will include 14 non-randomly varying predictors (*p*.) and two randomly-varying predictors (m_j).

Social context is represented by the main and interactive effects of three non-randomly varying demographic characteristics: socioeconomic status, gender, and racial-ethnic status. Socioeconomic status (SES) measures differences in achievement associated with family advantage conferred by level of parental education. Two dichotomous measures (*i.e.*, Male and Minority) will be included to control for gaps in achievement that could be explained by gender or minority status, respectively. Two student-level protective factors will be included to estimate the influence of positive attitudes and beliefs (Outlook) and home environments that foster literacy (Homeenv). Positive associations will support compensatory models of resilience. Interactions of student-level protective factors with social context will reveal whether protective factors foster reliance more in some social contexts than in others.

The within-school regression equations vary as a function of mean school achievement and the relative strength of the effects of $p + m$ student characteristics. The level-one equation for predicting an outcome for individual *i* in class *j* is: $Y_{ij} = \beta_{0j} + S\beta_{pj}(X_p) + S\beta_{mj}(X_m) + r_{ij}$. All student-level characteristics (X_p or X_m) will be grand-mean centered. Because random variance components are not estimated for non-randomly varying predictors (β_{pj}), the *p*th slope coefficient in every school *j* will be equal to the grand mean of the respective slope coefficient, (γ_{p0}), for all schools. Slope coefficients for two randomly-varying predictors (β_{mj}) represent mean effects of student characteristics for students within school *j*. The within-school equation can be interpreted as follows:

β_{0j} is the mean outcome of all students in class *j*;

β_{1j} is the difference in achievement in school *j* associated with 1 SD change in socioeconomic status;

β_{2j} is the gender gap in achievement in school *j*;

β_{3j} is the minority gap in achievement in school *j*;

β_{4j} is the two-way interaction of SES and gender with achievement in school *j*;

β_{5j} is the two-way interaction of SES and minority status with achievement in school *j*;

β_{6j} is the two-way interaction of gender and minority status with achievement in school *j*;

β_{7j} is the three-way interaction of SES, gender, and minority status with achievement in school *j*;

β_{8j} is the effect of Outlook on achievement in school *j*;

β_{9j} is the effect of Homeenv on achievement in school *j*;

$\beta_{10j.}$ is the two-way interaction of SES and Outlook with achievement in school *j*;

β_{11j} is the two-way interaction of gender and Outlook with achievement in school *j*;

β_{12j} is the two-way interaction of minority status and Outlook with achievement in school *j*;

β_{13j} is the two-way interaction of SES and Homeenv with achievement in school *j*;

β_{14j} is the two-way interaction of gender and Homeenv with achievement in school *j*;

β_{15j} is the two-way interaction of minority status and Homeenv with achievement in school *j*;

β_{16j} is the two-way interaction of Outlook and Homeenv with achievement in school *j*;

r_{ij} is the deviation of person *i* from mean achievement of class *j* when 16 ($p + m$) social context or protective effects are controlled.

Between-School Model. Our between-school model will estimate the direct effects of two school qualities (W_q) on the mean school achievement and the cross-level interactions of school effects with student-level characteristics. Two variables, School Climate (W_1) and Learning Experiences (W_2) will be added at level two to estimate the direct and indirect protective effects of the quality of the school environment on science achievement.

To reduce the size of the covariance matrix, 14 slope coefficients associated with social context will be fixed and allowed to vary non-randomly. The equation for estimating the p^{th} non-randomly varying slope coefficient is: $\beta_{p.} = \gamma_{p0}$. Each γ_{p0} is the grand mean of slope coefficient *p* for all schools. The equation for estimating the m^{th} randomly varying slope coefficient associated with protective effects for group *j* is: $\beta_{mj} = \gamma_{m0} + \mu_{mj}$. Here, γ_{m0} is the grand mean of slope coefficient *m* for all schools and μ_{mj} is the deviation of slope coefficient *m* in school *j* from the average value of slope coefficient *m*.

The level-two equations are:

β_{0j} = $\gamma_{00} + \gamma_{01}$(School Climate) + γ_{02}(Learning Experiences) + μ_{0j};

β_{pj} = $\gamma_{p0} + \gamma_{p1}$(School Climate) + γ_{p2}(Learning Experiences); and

β_{mj} = $\gamma_{m0} + \gamma_{m1}$(School Climate) + γ_{m2}(Learning Experiences) + μ_{mj}.

Because measures of school quality will be grand-mean centered, the level-two equations can be interpreted as follows:

γ_{00} is the grand mean science achievement for classes where the quality of school climate and students' learning experiences are average;

γ_{01} is the deviation in achievement associated with 1SD change in school climate;

γ_{02} is the deviation in achievement associated with 1SD change in the average quality of students' learning experiences at the school;

μ_{0j} is the deviation of class *j* from γ_{00} when school climate and learning experiences are controlled;

γ_{p0} is the average effect of the p^{th} characteristic or interaction on individual achievement;

γ_{p1} is the deviation from γ_{p0} associated with a one-unit change in school climate;

γ_{p2} is the deviation from γ_{p0} associated with a one-unit change in the quality of students' learning experiences at the school;

γ_{m0} is the average effect of the m^{th} student social context characteristic, Outlook or Home Environment, on individual achievement;

γ_{m1} is the deviation from γ_{m0} associated with a one-unit change in school climate;

γ_{m2} is the deviation from γ_{m0} associated with a one-unit change in the quality of students' learning experiences at the school; and

μ_{mj} is the deviation of class *j* from γ_{m0} when school climate and learning experiences are controlled.

The expanded equation for the between-school model with *m* + 1 variance components is:

$Y_{ij} = (\gamma_{00} + S\ \gamma_{0q}W_{qj} + \mu_{0j}) + S(\gamma_{p0} + S\ \gamma_{pq}W_{qj})(X_{ij}) + S(\gamma_{m0} + S\ \gamma_{mq}W_{qj} + \mu_{mj})(X_{ij}) + r_{ij}$.

Significance of the Study.

The proposed analysis will compare differences in the impact of protective factors and educational policies and practices in social contexts. Estimates of associations of the main effects of gender, SES, or minority status, and their two-way and three-way interactions, will help to identify the extent to which social context mediates achievement. These findings will be useful for testing explanations for resilience supported by compensatory and multiplicative models. Student- and school-level protective factors that have significant non-zero association with average achievement may improve resilience overall, regardless of social context. Protective factors that have significant non-zero associations with demographic status variables may be useful for identifying interactive situational mechanisms that moderate achievement in social contexts. Evidence of systematic differences in the association of social context with achievement may be explained by differences in the mediating effects of school-level protective factors. Analyzing protective factors in different social contexts may help explain why some groups of individuals statistically are more vulnerable than others, and why some individuals at risk are more resilient than others.

Available NAEP publications report achievement differences among policy-relevant groups but do not address the substantial within-group heterogeneity that accounts for variability in science achievement among students with similar demographic profiles. The proposed research is intended to improve the precision with which NAEP estimates group and subgroup performance and to stimulate discussion about the relative effectiveness of educational interventions for students at risk. A caveat is in order with regard to interpretation of associations of protective factors with achievement. While the proposed approach is intended to encourage thinking about how processes and policies operating at the individual, home, and school levels of a child's educational environment mediate science achievement, causal inference based on results of the analysis is unjustified. These comparisons are designed to produce suggestive results that stimulate discussion about the sources of variation for students at risk, the relative effectiveness of interventions and policies for students at risk, and about plausible mechanisms for school improvement. They may inform policy, but should not prescribe it.

PERSONNEL

This application seeks funding from the National Center for Education Statistics to conduct research at the Department of Measurement, Statistics, and Evaluation (EDMS) in the College of Education at the University of Maryland, College Park (UM). The proposed research project will span 18 months and involve two EDMS faculty members, Dr. Clare Von Secker (25% time/year) and Dr. Robert W. Lissitz (5% time/year); one advanced EDMS doctoral student (50% time for 10 months); and one consultant, Dr. Mislevy, (2 days). Curriculum vitae of key personnel are provided in Appendix B.

Project director, Dr. Clare Von Secker.

Contribution to the Proposed Project. Dr. Von Secker will be the project director and oversee all aspects of the project. For each investigation area, Dr. Von Secker, in collaboration with Dr. Lissitz, will monitor the quality and timeliness of all tasks associated with the proposed research including project initiation, data preparation, statistical analyses, and dissemination of results. Dr. Von Secker will work with the research assistant to prepare datasets for analysis with SPSS, conduct initial statistical analyses using SPSS and EXCEL, conduct PCA analysis to extract protective factors, assign individuals to social context groups, conduct HLM analysis, organize HLM output, calculate effect sizes, outline draft findings, and discuss draft findings with co-project director, Dr. Lissitz. The co-project directors have found this approach successful in current and past projects involving secondary analysis of NCES datasets. The project directors will share draft findings with colleagues and consultants prior to preparation of final reports. Dr. Von Secker will be the lead author for the technical report, conference presentations, and journal articles.

Qualifications. Dr. Von Secker is Adjunct Associate Professor for EDMS. She has been working with NAEP and other NCES datasets for over six years. In 1995 and 1999 she was invited to participate in HLM training institutes sponsored by the American Educational Research Association (AERA). In 1996 she completed an intensive one-week summer seminar with Dr. Stephen Raudenbush on the use of HLM. Since 1995, Dr. Von Secker has served as a research assistant and consultant to tenured faculty at the University of Maryland who obtained site licenses to have access to restricted NCES datasets. Dr. Von Secker has co-authored several papers and presentations reporting analyses of data from NAEP, the High School Effectiveness Study, and from the National Education Longitudinal Study (NELS). In 1998, Dr. Von Secker was awarded a dissertation grant from AERA to conduct analysis of NELS. Her areas of specialization are applied statistics, evaluation, and policy analysis. Recent research has applied HLM to estimate effects of curriculum and instruction on student outcomes and to evaluate school effectiveness.

From 1992 to 1994, Dr. Von Secker served as Director for Science Education Programs with the National Institute of Mental Health. She was the project officer in charge of planning, administering, and overseeing contract and grant programs to develop innovative, model approaches to science education for school age children and their parents. Activities of her office included development of computer technology, print-based curriculum materials, and enrichment activities aimed at improving science education and public understanding of science. During the 1994 to 1995 academic year, Dr. Von Secker worked at Johns Hopkins University as an instructional specialist, writer, and teacher trainer for a national reform project aimed at improving elementary science education. Of particular interest for this project is Dr. Von Secker's dual expertise as a researcher familiar with the strengths, peculiarities, and limitations of

NAEP data and as an educator who understands how to communicate findings in a way that will be meaningful and useful to science practitioners and to policy makers.

Co-Project Director, Dr. Robert W. Lissitz.

Contribution to the Proposed Project. Dr. Lissitz will serve as administrative liaison for the project, will coordinate the administrative aspects of the grant, and facilitate communication between the University of Maryland and NCES. As co-project director he will be responsible for data security, coordinating on and off campus personnel, maintaining records, preparing budget reports, collaborating on preparation of publications and progress reports, and overseeing computer maintenance, software, and back up.

Qualifications. Dr. Lissitz is Professor and Chair of EDMS. He obtained a site license to analyze restricted NCES datasets in 1995 and is experienced in analysis of NAEP data. Dr. Lissitz has taught courses for EDMS on using HLM to conduct secondary analysis of NAEP and other large datasets. He has served as a statistical consultant to faculty members in other departments in the College of Education who use NAEP for policy analysis. Dr. Lissitz has been in demand as a consultant with a number of major projects including his earlier evaluation of the court-ordered desegregation effort in St. Louis and developing a computer adaptive testing system for a large agency of the federal government. Dr. Lissitz serves as chair of a number of committees for the National Council on Measurement in Education and the AERA. His broad network of friends and acquaintances within the educational statistics community provides an invaluable informal resource for EDMS faculty and students. Of particular interest for this project is Dr. Lissitz's combined administrative expertise and knowledge of the technical and psychometric aspects of NAEP.

Other Project Personnel.

Research Assistant. An advanced EDMS doctoral student will be hired to work as a research assistant prepare datasets for analysis with SPSS, conduct initial statistical analyses using SPSS and EXCEL, conduct PCA analysis to extract protective factors, assign individuals to social context groups, conduct HLM analysis, organize HLM output, calculate effect sizes, outline draft findings. The research assistant will be located in one office of a research suite that includes the co-project directors' offices to facilitate informal daily interactions about research progress. The co-project directors have found this approach successful in current and past projects involving secondary analysis of NAEP datasets.

Consultant.

One of foremost authorities on NAEP, Dr. Robert Mislevy has agreed to be a consultant for us on the proposed project. Dr. Mislevy is a member of EDMS and will be available on a regular basis for informal consultation. His informal, but consistent, participation in the proposed project will improve the quality of our research plan, ensure that we use methodological tools appropriately, lend credibility to our findings, and promote dissemination of our results. A curriculum vitae for Dr. Mislevy is on file at NCES and available upon request from the applicants.

Dr. Robert Mislevy. Dr. Mislevy is an eminent statistician whose contribution to interpretation of NAEP is perhaps unrivaled. There is perhaps no person better qualified to guide and evaluate our proposed approach to presentation of the Nation's Report Card. Dr.Mislevy will review our data analysis plan, help with statistical quality control, and provide extensive manuscript edits to ensure that our reports are accurate, valid, and coherent.

MANAGEMENT PLAN

A high degree of productivity for the proposed project is possible because key personnel have already made significant investments in the investigations of related questions and the use of appropriate methodology for analysis of NAEP datasets. Drs. Von Secker and Lissitz have been meeting regularly for five years on a series of NCES research projects and have developed a stable and productive working relationship.

Description of Project Tasks.

We have organized our management plan around three major tasks: (1) project initiation; (2) data analysis; and (3) dissemination of project results.

Task 1: Project Initiation (Months 0-3). In early 2000 the applicants obtained and began to conduct preliminary examination of the restricted 1996 main, trend, and state science assessments. We plan to compare results from the 4th, 8th, and 12th grade 1996 main assessment data sets in our proposed analysis. The 1996 datasets have plausible values estimating science achievement, sampling weights, demographic information about students, questions about students attitudes toward science, questions about home environments, and responses of school administrators to questions about school characteristics and policies.

Subtask 1.1: Refine research and analysis plan (Months 0-3). As part of our project initiation activities, we will invite our Contracting Officer's Technical Representative (COTR) to review our proposal and have our consultant provide feedback and comments. They will examine descriptive statistics we obtain for our sample, inspect correlations among variables in the model, review our methodology, identify ways the analytical model may be respecified, and provide general suggestions for improving the project. This discussion will be conducted primarily via email over the Internet.

Subtask 1.2: Prepare datasets (Months 1-3). We have already obtained and conducted preliminary examination of the NAEP assessment data from the 1996 science assessment. We will use the SPSS syntax files provided on the CD-ROM to create SPSS student and school data files for grade 4 (Y27sci09.sys and Y27scq09.sys), grade 8 (Y27sci13.sys and Y27scq13.sys), and grade 12 (Y27sci17.sys and Y27scq17.sys). Variable and value labels will be included in our data files. The extracted data files will be thoroughly “cleaned” to ensure data quality for the research sample. We will calculate descriptive statistics, examine residuals, produce frequency tables for each variable, make a correlation matrix of all variables in the model, and examine cross-tabulations of variables in combination with one another. Preliminary graphical analyses will be used to explore relationships between protective factors and social context.

<u>Task 2: Data Analysis (Months 4-11)</u>. Data analysis consists of four phases: computation of composite measures of protective effects; assignment of individuals to social context groups and creation of SSM files; generation of parameter estimates from HLM; and calculation of effect sizes based HLM analyses, and comparison of results for grades 4, 8, and 12. Our consultant will review results as we obtain them. We recognize that we may conduct additional analyses as we are writing up the results during months 12 to 18.

Subtask 2.1: Conduct PCA (Months 4-5). Principal components analysis (PCA) will be used to extract a total of 3 standardized factors that represent different protective effects. One factor measuring student attitudes and beliefs will be weighted composites derived from eight questions that measure students’ attitudes about science and their beliefs about their ability to do well in science. A second composite measuring school climate will be weighted composite derived from 19 items that ask school administrators about the quality of the school climate. A

third composite measuring the quality of students' learning experiences will be derived from a weighted composite of 30 items that ask about students experiences in science classes.

Subtask 2.2: Create SSM files for grades 4, 8, 12(Months 6-7). One hierarchical linear model (HLM) may be used to calculate the average effects of protective factors on science achievement for all students at each grade level.

Subtask 2.3: Conduct HLM analysis (Months 8-9). We will use the current version of the HLM program to compute parameter estimates for each model. HLM output files for each model will be printed to facilitate data quality control. Values for fixed and random parameter estimates for fully unconditional, unconditional within-school, and conditional between-school models will be transferred to a Micosoft Excel spreadsheet and displayed in tabular form to facilitate examinations of residuals, graphic analysis, calculations of effect sizes, and incorporation of results into documents prepared using Microsoft Word.

Subtask 2.4: Cross-grade comparisons (Months 10-11). We will use descriptive statistics to compare effect sizes for students in grades 4, 8, and 12. This analysis will help to identify differences in the relative sizes of protective effects for individuals of different ages and may guide future research.

Task 3: Dissemination of Project Results (Months 12– 18). The project will deliver a series of products of potentially major significance to interpretation and future analysis of NAEP data. The key products of the research will be a comprehensive technical report, conference presentations, and a substantive paper suitable for publication by NCES and in a professional journal. The products, though based on rigorous analyses, will be broadly accessible and will consider policy alternatives in light of a synthesis of output from the multilevel models.

Subtask 3.1: Prepare technical report (draft due month 15; final due month 18). After analysis has been completed, we will produce a detailed technical report of our findings. The report will contain an executive summary, introduction, background information, methods, results, recommendation for operations, recommendations for further research, and appendices. Part of the technical report will be submitted for posting at the ERIC/AE web site that currently is visited by 4,000 users per week.

Subtask 3.2: Prepare conference presentations (drafts due month 15; final month 18). We will submit our findings for conference presentations at the annual meetings of AERA and the National Science Teachers Association (NSTA).

Subtask 3.3: Prepare journal articles (drafts due month 15; final month 18). We will prepare articles containing concise summaries of our research findings that are suitable for publication in refereed journals

Staff Responsibilities.

Dr. Von Secker will be primarily responsible for completion of Tasks 1, 2, and 3, and will regularly monitor progress of the research assistant in completing subtasks 1.2 and 2.1 – 2.4. Drs. Von Secker and Lissitz will review findings with consultants prior to preparation of final reports. Dr. Von Secker will have primary responsibility for dissemination of project results.

RESOURCES

Institutional Support.

The College of Education and key personnel have all of the equipment and resources necessary to conduct this project. The EDMS department will provide all hardware and software including Pentium III computers, laser printers, SPSS 9.0 and the most recent version of HLM. The project builds on our current work with NAEP. We already have worked with the 1994 NAEP reading datasets and have conducted preliminary examination of NAEP 1996 main and state assessment datasets. We have a sound security plan for the data, and preliminary analyses have informed our current design. It is for these reasons that we feel it is realistic to set ambitious goals with a comparatively modest budget.

NAEP License.

EDMS has had a license for analysis of NAEP data and other NCES privileged datasets since 1995. Over the last five years, Drs. Lissitz and Von Secker have been connected with many projects involving analysis of NAEP data to investigate correlates of achievement in grades 4, 8, and 12. As a result of these projects and through training sponsored by NCES and AERA, the project directors have developed experience with NAEP methodology and analysis of NAEP data.

Equal Opportunity Statement (Pursuant to Section 427 of GEPA).

Given the purposes of the project, no participants will be selected for the research. However, the University of Maryland already implements effective steps to ensure equity of access and participation in other grant programs. The University of Maryland is an Equal Opportunity Affirmative Action Employer, and any hiring that results from funding of the project will be accomplished in strict conformity to that policy. Products resulting from the proposed research will be offered in a variety of formats, including conference presentations, Internet postings on the ERIC web site, and journal articles. The multimodal nature of our dissemination plan will promote equitable access to this information for all individuals, regardless of gender, race, national origin, color, disability, or age.

Time Commitments.

Given the numerous efficiencies built into the proposed project, the time commitments of the project directors, research assistant, and consultants are adequate to accomplish all tasks with a high level of quality. Dr. Von Secker will commit 25% of her time with EDMS for 18 months to complete the analysis and disseminate findings through final reports and conference presentations. Dr. Lissitz will commit 5% of his time for 18 months as Professor and Chair for EDMS to oversee administrative aspects of the grant and to collaborate with Dr. Von Secker.

We anticipate that we will have no problem scheduling meetings with our consultant at mutually convenient times. Dr. Mislevy is a Professor with EDMS and has an office on our College Park campus. The relative proximity and the compatibility of the schedules of key personnel and consultants will enhance project efficiency and progress.

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APPENDIX A: PRINCIPAL COMPONENTS ANALYSIS ITEMS

Table A1

Attitudes and Beliefs

NUMBER	VALUE LABEL
K811001B	AGREE/DISAGREE: I LIKE SCIENCE
K811002B	AGREE/DISAGREE: I AM GOOD AT SCIENCE
K811003B	AGREE/DISAGREE: LEARNING SCI MOSTLY MEMORIZATION
K811004B	AGREE/DISAGREE: SCI USEFUL FOR EVERYDAY PROBLEMS
K811005B	AGREE/DISAGREE: IF CHOICE, WOULD NOT STUDY SCIENCE
K811006B	AGREE/DISAGREE: ALL CAN DO WELL IN SCI IF THEY TRY
K811007B	AGREE/DISAGREE: SCIENCE IS BORING
K811008B	AGREE/DISAGREE: SCIENCE IS A HARD SUBJECT

Table A2

School Climate Items

NUMBER	VALUE LABEL
C032402	IS STUDENT ABSENTEEISM A PROBLEM IN YOUR SCHOOL?
C032401	IS STUDENT TARDINESS A PROBLEM IN YOUR SCHOOL?
C032404	ARE PHYSICAL CONFLICTS A PROBLEM IN YOUR SCHOOL?
C032406	IS TEACHER ABSENTEEISM A PROBLEM IN YOUR SCHOOL?
C032407	ARE RACIAL/CULTURAL CONFLICTS A PROBLEM IN SCHOOL?
C032408	IS STUDENT HEALTH A PROBLEM IN YOUR SCHOOL?
C032409	IS LACK OF PARENT INVLVMNT A PROBLEM IN SCHOOL?
C032410	IS STUDENT ALCOHOL USE A PROBLEM IN YOUR SCHOOL?
C032411	IS STUDENT TOBACCO USE A PROBLEM IN YOUR SCHOOL?
C032412	IS STUDENT DRUG USE A PROBLEM IN YOUR SCHOOL?
C032413	ARE GANG ACTIVITIES A PROBLEM IN YOUR SCHOOL?
C032414	IS STUDENT MISBEHAVIOR A PROBLEM IN YOUR SCHOOL?
C032415	IS STUDENT CHEATING A PROBLEM IN YOUR SCHOOL?
C032502	TEACHER MORALE (HOW POSITIVE)?
C032503	STUDENT ATTITUDES TOWARD ACADEMIC ACHIEVEMENT?
C032505	PARENT SUPPORT FOR STUDENT ACHIEVEMENT?
C032506	REGARD FOR SCHOOL PROPERTY?
C033601	% OF STUDENTS ABSENT ON AVERAGE DAY?
C036501	% OF TEACHERS ABSENT ON AVERAGE DAY?

Table A3

Quality of Learning Experiences Items

NUMBER	VALUE LABEL
K811101B	EVER DONE HANDS-ON PROJECT WITH LIVING THINGS?
K811102B	EVER DONE HANDS-ON PROJECT WITH ELECTRICITY?
K811103B	EVER DONE HANDS-ON PROJECT WITH CHEMICALS?
K811104B	EVER DONE HANDS-ON PROJECT WITH ROCKS OR MINERALS?
K811105B	DONE HANDS-ON PROJ W/ MAGNIFYING GLASS/MICROSCOPE?
K811106B	DONE HANDS-ON PROJ W/ THERMOMETER OR BAROMETER?
K811107B	EVER DONE HANDS-ON PROJECT WITH SIMPLE MACHINES?
K811108B	HAVE DONE HANDS-ON PROJECT WITH NONE OF THE ABOVE?
K811301B	HOW MUCH TIME PER WEEK DOING SCIENCE HOMEWORK?
K811401B	DO SCI PROJECTS IN SCHOOL THAT TAKE 1 OR MORE WKS?
K811501B	LAST 2 YRS, BEEN IN SCI FAIR, FESTIVAL, SCI DAY? '
K811601B	FOR SCI IN SCHOOL, HOW OFTEN DO YOU READ TEXTBOOK?
K811602B	FOR SCI IN SCHOOL, HOW OFTEN DO YOU READ MAGS/BKS?
K811603B	FOR SCI IN SCHOOL, HOW OFTEN DISCUSS SCIENCE NEWS?
K811604B	FOR SCI IN SCHOOL, HOW OFTEN WORK WITH OTHERS?
K811605B	FOR SCI IN SCHOOL, HOW OFTEN GIVE ORAL REPORT?
K811606B	FOR SCI IN SCHOOL, HOW OFTEN GIVE WRITTEN REPORT?
K811607B	FOR SCI IN SCHOOL, HOW OFTEN DO HANDS-ON PROJECT?

Table A3

Quality of Learning Experiences Items

K811608B	FOR SCI IN SCHOOL, HOW OFTEN DISCUSS RESULTS?
K811609B	FOR SCI IN SCHOOL, HOW OFTEN DO YOU USE COMPUTER?
K811611B	FOR SCI IN SCHOOL, HOW OFTEN DO YOU USE LIBRARY?
K811612B	FOR SCI IN SCHOOL, HOW OFTEN OBSERVE/MEAS OUTSIDE?
K811701B	HOW OFTEN DOES SCIENCE TEACHER TALK TO CLASS?
K811702B	HOW OFTEN DOES SCIENCE TEACHER DO DEMONSTRATION?
K811703B	HOW OFTEN DOES SCIENCE TEACHER SHOW VIDEO OR TV?
K811704B	HOW OFTEN DOES SCIENCE TEACHER USE COMPUTER?
K811705B	HOW OFTEN DOES SCI TEACHER USE CD"S/LASER DISCS?
K811801B	HOW OFTEN DOES SCI CLASS GO ON A FIELD TRIP?
K811901B	HOW OFTEN DOES GUEST SPEAKER COME TO SCI CLASS?

APPENDIX B: LETTER OF COMMITMENT FROM CONSULTANT

Letter received via email January 3, 2001.

X-Originating-IP: [24.4.252.65]
From: "Robert Mislevy" <ramrjm2@hotmail.com>
To: rl27@umail.umd.edu
Cc: clare@cais.net
Subject: Re: grant
Date: Tue, 02 Jan 2001 22:05:07 -0500

Dear Prof. Lissitz:

Thank you for the opportunity to serve as a consultant on the proposed project "Science Achievement in Social Context," to be headed by Dr. Clare Von Secker. I would be pleased to do so.

Sincerely,
Robert J. Mislevy, Professor

Department of Measurement, Statistics, and Evaluation
University of Maryland

APPENDIX C: CURRICULUM VITAE OF KEY PERSONNEL

CV

Clare Von Secker, Ph.D.
4515 Willard Avenue, #2104
Chevy Chase, MD 20815
301-652-2851
clare@cais.net

EDUCATION

B. S., Science Education/Biology, University of Maryland, 1974
M.Ed., Curriculum and Instruction, University of Maryland, 1979
Ph.D., Measurement, Statistics, and Evaluation, University of Maryland, 1998

BIOSKETCH

Dr. Clare Von Secker currently is Adjunct Associate Professor in the Department of Measurement, Statistics, and Evaluation at College Park. Her areas of specialization are applied statistics, evaluation, and policy analysis. Recent research has applied techniques of hierarchical linear modeling (HLM) and meta-analysis to estimate effects of curriculum and instruction on student outcomes and to evaluate school effectiveness. Dr. Von Secker has taught several courses for EDMS in the areas of assessment and evaluation. In addition to her teaching and research at the university she is active as a consult and advisory panel member for projects sponsored by the National Science Foundation, the National Institutes of Health, and the Chesapeake Bay Foundation.

Dr. Von Secker has worked with Montgomery County Public Schools (MCPS) for 25 years. Besides teaching science, she developed and taught a wide range of elective courses including biotechnology research and science internship classes for gifted high school students, a communications course for eighth graders, and a group-counseling program for emotionally disabled students. Dr. Von Secker has worked extensively as a writer and editor for MCPS curriculum projects in science and mathematics. She has presented numerous workshops for teachers on topics such as interpretation of science research, teaching critical thinking and writing, and differentiating science instruction to accommodate different teaching and learning styles.

From 1992 to 1994, Dr. Von Secker served as Director for Science Education Programs with the National Institute of Mental Health. Activities of her office included development of computer technology, print-based curriculum materials, and enrichment activities aimed at improving science education and public understanding of science. She was the project officer in charge of planning, administering, and overseeing contract and grant programs to develop innovative, model approaches to science education for school age children and their parents. During the 1994 to1995 academic year, Dr. Von Secker worked at Johns Hopkins University as an instructional specialist, writer, and teacher trainer for a national reform project aimed at improving elementary science education.

TEACHING EXPERIENCE

1999 - Present: Introduction to Program Evaluation and Basic Statistics

This graduate course in evaluation, offered through the department of Educational Measurement and Statistics at the University of Maryland, provides masters and doctoral students with a general overview of theoretical strands and methodological issues associated with the design and implementation of program evaluations. The course in basic statistics provides an introduction to descriptive and inferential statistics.

1995 - Present: Science Teacher and Science Intern Coordinator

I am currently teaching physical science at Walt Whitman High School in Bethesda, Maryland. In addition, I coordinate a school-based science internship program and supervise high school students who work with local scientists at various locations, including the David National Institutes of Health, Georgetown University, American University, and the University of Maryland.

1994 - 1995: Classroom Assessment for Pre-service Teachers

This course, offered through the department of Educational Measurement and Statistics at the University of Maryland, provides junior and senior elementary education majors with a general overview of issues and practices in classroom assessment, state and national assessments, and teacher accountability.

1975 - 1992: Science, Grades 7 - 9

My experience at all grade levels includes classes of Gifted and Talented, Basic Skills, average, Level 4, and ED/LD students as well as heterogeneous classes.

1978 - 1979: Health -- Grade 9

The content of this class is now incorporated into the eighth grade Family Life physical education program.

1983 - 1988: Contemporary Communications -- Grade 8

I wrote this nine-week visual literacy elective course as a companion to a computer literacy elective.

1985 - 1986: Social Skills Education -- Grades 8 and 9

I wrote this daily group counseling program as part of an alternative school program for students with histories of school failure and emotional problems.

1991 - 1992: Computer Keyboarding -- Grade 6

A 4-5 week "typing" course which uses the PAWS program to teach proper keyboarding skills and improve typing speed.

1987 - 1995: Adult Ballroom Dancing

Private and group classes at a variety of locations in the Washington, D. C. area including Chevy Chase Ballroom, the Smithsonian Resident Associates Program, the Kennedy Center, and American University.

EDUCATIONAL CONSULTING EXPERIENCE

1992 - Present: PROGRAM DEVELOPMENT AND EVALUATON

As an **Independent Consultant**, I have had responsibilities for:

program evaluation, including:

-- test development and psychometric analysis of measurements
-- informative and summative evaluation of science education programs

program development, including

-- stimulating and supporting development of science curricula that are consistent with State and National Science Education Standards
-- designing and writing Teacher's Guides
-- integrating curricula with computer technologies

teacher training, including

-- designing and presenting workshops that focus on methods for helping teachers and students develop critical thinking skills and scientific habits of mind
-- coordinating teacher fellowship programs for high school teachers and scientists
-- designing and presenting workshops for teachers of gifted and talented students on topic such as differentiating science instruction, meeting the affective needs of G&T students, teaching critical writing, and accommodating different teaching styles and learning styles
-- presenting orientation programs for interdisciplinary groups of teachers new to MCPS

ADMINISTRATIVE EXPERIENCE

1992 - 1994: DIRECTOR, SCIENCE EDUCATION PROGRAMS, NIMH

My duties as **Science Education Director for the National Institute of Mental Health** included:

-- conducting a national program to encourage innovation and foster quality efforts in the area of science education, with particular emphasis on brain science, with a goal of improving biomedical science education and public understanding of science in the United States
-- coordinating development of CD-ROM computer technologies for biology classes
-- coordinating development of technology-based secondary life science curricula, materials and enrichment activities, including computer technology and laboratory-based experiences
-- maintaining liaison with national science teacher organizations, and developing and carrying out jointly sponsored activities such as teacher institutes, projects to prepare and disseminate material to teachers, and meetings which bring together teachers and scientists
-- promoting opportunities to provide laboratory experience for teachers and students at the K-12 levels
-- planning and administering contract and/or grant programs to develop innovative, model approaches to science education for school age children and their parents
-- serving as Program Officer for the NIMH Science Education Partnership Program (SEPA)
-- overseeing SEPA grant annual review and award cycles, payments and budgets; organizing grantees' meetings; and assessing the effectiveness of funded institutions' science education activities
-- fostering inclusion of curricula/programs in brain and behavioral sciences in programs for gifted and talented students
-- stimulating and supporting model museum-based science education activities for school age children and their parents
-- promoting and supporting public television programs on science
-- working with national curriculum development projects
-- supporting model community-based science education programs
-- promoting the involvement of scientists in science education activities
-- stimulating efforts of university students to carry out science education activities directed toward children and the general public
-- working with national organizations representing various types of community and civic groups and to stimulate development of science education programs, with particular emphasis on mental health
-- planning, setting priorities, developing, conducting, and evaluating science education programs

SCIENCE CURRICULUM DEVELOPMENT EXPERIENCE

1998-1999: MATTER AND ENERGY (MCPS)

As an **Editor**, I was responsible for

-- reviewing and updating the ninth grade science curriculum for Montgomery County Public Schools
-- teaching writers how to write SAT preparation critical thinking activities
-- designing rubrics for teaching reading strategies
-- matching MCPS objectives with Maryland State Science Objectives and the 5E Learning Model

As a **Writer**, I was responsible for

-- writing and revising the ninth grade science curriculum for Montgomery County Public Schools
-- writing SAT preparation critical thinking activities
-- matching MCPS objectives with Maryland State Science Objectives

1994 - 1995: ROOTS AND WINGS (Johns Hopkins University)

As **Project Facilitator**, I have responsibilities for:

-- writing a technology-based integrated elementary science curriculum
-- training elementary school teachers to implement curriculum

1992: EVENT-BASED SCIENCE (MCPS/NSF)

As a **Writer**, I had responsibilities for:

-- designing a science curriculum reflecting the event-based model
-- writing inquiry-oriented science activities
-- promoting incorporation of cooperative learning strategies
-- matching EBS objectives with Maryland State science objectives
-- matching EBS objectives with AAAS Project 2061 objectives

1990: INTERDISCIPLINARY MATH-SCIENCE CURRICULUM DEVELOPMENT (MCPS)

As a **Writer**, I was responsible for:

-- identifying connections between the math and science programs of study
-- writing science-based lessons which incorporated the math objectives

1986: MARK TWAIN SCIENCE PROJECT: BRIGHT SCIENCE IDEAS (MCPS)

As **Project Coordinator** I was responsible for:

-- conducting needs assessment for Mark Twain Staff
-- in-service training for science teachers
-- development of a differentiated Program of Studies for special education students
-- writing sample lesson plans to match Program of Studies objectives for Grades 7-9
-- production of a draft copy of the Program of Studies
(edited draft distributed in 1987 to MCPS Special Education Teachers)

1979: INTERDISCIPLINARY GUIDE FOR GIFTED AND TALENTED (MCPS)

As a **Writer** I was responsible for:

-- production of differentiated lesson plans for gifted and talented students
-- team development of interdisciplinary lessons which focused on particular higher order thinking skills

HONORS

1998 American Educational Research Association Dissertation Grant Award
1996 Howard Hughes Medical Institute Summer Intern
1995 International Testing and Evaluation Association Scholarship winner

1989 Associate Degree, Latin Branch, Imperial Society of Teachers of Dancing, London, England
1988 Licentiate Degree, Ballroom Branch, Imperial Society of Teachers of Dancing, London, England
1987 Associate Degree, Ballroom Branch, Imperial Society of Teachers of Dancing, London, England

INVITED PRESENTATIONS

2001 *Using Hierarchical Linear Growth Models to Evaluate Protective Mechanisms that Mediate Science Achievement*. Paper accepted for presentation at the American Educational Research Association Annual Convention, Seattle, Washington.

2001 *Effects of Inquiry-Based Teacher Practices on Science Excellence and Equity*. Paper accepted for presentation at the American Educational Research Association Annual Convention, Seattle, Washington.

2000 *Results of a Pilot Evaluation of the NIH Science Curriculum Supplements*. Report prepared for the National Institutes of Health Office of Science Education. Presented at BSCS Headquarters, Colorado Springs, Colorado.

2000 *Feasibility Evaluation of the Effects Of Inquiry-based Teacher Practices On Science Achievement*. Evaluation prepared for the National Institutes of Health Office of Science Education. Presented at BSCS Headquarters, Colorado Springs, Colorado.

1999 *Effects of Instructional Practices on Science Achievement in Social Contexts.* Research presented as part of NIH-sponsored curriculum workshops for high school science teachers at the National Association of Biology Teachers Annual Convention, Fort Worth, Texas

1998 *Using Statistical Methods to Promote Critical Thinking in Science Classrooms: Practical Applications for High School Teachers.* NSF-sponsored workshop for high school science teachers presented at the University of Wisconsin, Madison.

1998 *Estimating the Impact of Instructional Practices on Student Achievement in Science*. Paper presented at the American Educational Research Association Annual Convention, San Diego, California.

1997 *Hypothesis Testing: Scientific Analysis of Laboratory Data*. Three-day workshop for high school science teachers presented at the University of Wisconsin, Madison.

1997 *Estimating School Value-Added Effectiveness: Consequences of Misspecification of Hierarchical Linear Models.* Paper presented at the American Educational Research Association Annual Convention, Chicago, Illinois

1996 *From Research Lab to Student Lab: Helping Students Think Like Scientists*, Second Annual Workshop of ASCI Fellowship Teachers, St. Louis, Missouri

1996 *Using the Internet to Find Funding Sources for Science Education Partnership Programs*, NIH Science Education Partnership Award Annual Meeting, Washington, D. C.

PUBLICATIONS

Guthrie, J. T., Schafer, W. D., Von Secker, C., & Alban, T. 2000. Contributions of integrated reading instruction and text resources to achievement and engagement in a statewide school improvement program. Journal of Educational Research, 93(4) 211-225.

Guthrie, J. T., Wigfield, A., & Von Secker, C. (in press). Effects of integrated instruction on motivation and strategy use in reading. Journal of Educational Psychology.

Schafer, W. Guthrie, J. T., & Von Secker, C. (1997). Achievement change and reading instructional strategies. Reading Research Report. University of Maryland, College Park: National Reading Research Center.

Von Secker, C., & Lissitz, R. W. (1999). Estimating the impact of instructional practices on student achievement in science. Journal of Research in Science Teaching, 36(10), 1110-1126.