THE EFFECT OF TEACHER CERTIFICATION

ON STUDENT ACHIEVEMENT

A Dissertation

by

KARIN SPARKS

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

May 2004

Major Subject: Educational Psychology

THE EFFECT OF TEACHER CERTIFICATION

ON STUDENT ACHIEVEMENT

A Dissertation

by

KARIN SPARKS

Submitted to Texas A&M University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Approved as to style and content by:

James F. McNamara (Chair of Committee)	Lisa O'Dell (Member)
Michael Ash (Member)	Stan Carpenter (Member)
Victor Willson (Head of Department)	

May 2004

Major Subject: Educational Psychology

ABSTRACT

The Effect of Teacher Certification on Student Achievement.

(May 2004)

Karin Sparks, B.A., University of New Mexico;

M.S., Texas A&M University

Chair of Advisory Committee: Dr. James F. McNamara

The purpose of this study was to review the empirical research evidence on the effect of teacher certification on student achievement. An exploratory meta-analysis was conducted on studies that examined the effect of fully certified and less-than-fully certified teachers on student achievement. The meta-analysis focused on the areas of mathematics, science and reading and explored trends across areas of achievement, school level and research design. The study was directed towards (a) a synthesis of findings, and (b) recommendations for future research and policy decisions.

The meta-analysis population consisted of five individual studies that generated twenty-seven effect size estimates. Three studies utilized either an individual level or class level of analysis and yielded twelve mean difference effect size estimates. Two studies utilized either a school or state level of analysis and yielded fifteen correlational effect size estimates.

The majority of findings in mathematics favor the positive effect of fully certified teachers. In science, the findings pointed towards equivalent levels of student

achievement for fully certified and less-than fully certified teachers. All the findings associated with reading favored the positive effect of fully certified teachers. It appears that certification may be more crucial to student achievement in reading and mathematics than in science.

Across school levels, the overall trend suggests that full certification may be more crucial to student achievement in elementary school than middle or high school. Across levels of analysis and research design, studies that utilize an aggregate level of analysis yield a greater number of positive study outcomes than designs conducted at the individual or class level.

A key finding is that given the specifications of the meta-analysis, direct evidence of the relationship between certification and student achievement is limited to five peer-reviewed, published studies. Additional findings illuminated several issues that are vital to improving the quantity and quality of research on teacher certification. Eight specific recommendations were directed towards academic researchers who plan to study the topic. Four recommendations are directed towards policy-makers at the state and federal level who are involved in setting standards and planning legislation for educator preparation.

ACKNOWLEDGEMENTS

I want to express my appreciation to Dr. Jim McNamara for his help in getting this dissertation off the ground and for his continued input and attention to detail. I would also like to thank committee members Dr. Mike Ash and Dr. Stan Carpenter for their support and feedback during the past year. Special thanks go to Dr. Lisa O'Dell who has been not only a great friend but a source of inspiration, guidance and support while I have been at Texas A&M University.

I would also like to thank Dr. Victor Willson, whose advice and classes have been instrumental in helping me achieve my educational goals. I am extremely grateful to Carol Wagner, whose advice and assistance is an invaluable component of the educational process.

Additionally, I would like to thank Dr. Bill Reaves for his support and encouragement. My position in his organization not only provided me with additional experience in educational research but ultimately inspired the topic for this dissertation.

Finally, my deepest gratitude goes to my husband, David. He provided technical assistance but more importantly, the emotional support needed throughout the dissertation process.

TABLE OF CONTENTS

LIST OF TABLES

TABLE Page

CHAPTER I

INTRODUCTION

Few would disagree that teachers are an essential factor in student achievement or that teacher quality is positively related to effective teaching practices. However, there is little consensus on the training and preparation that lead to effective teaching (U.S. Department of Education, 1999). Teacher certification is intended to ensure teacher quality by regulating the training of prospective teachers in effective teaching practices. Two educational policy organizations have produced narrative syntheses of research on the effect of certification on student achievement. The National Commission on Teaching and American's Future is a primary advocate for certification as an effective means of ensuring teacher quality and effective teaching in the public schools (Focus on Teaching Quality, 2001). In contrast, The Abell Foundation argues that teacher certification as it currently exists does not ensure effective or quality teachers. Moreover, the organization contends that there is no credible research evidence that warrants current preparation requirements (Walsh, 2001).

Citations follow the style of the *American Educational Research Journal.*

Each organization has produced a narrative synthesis of research on the effect of certification on student achievement, but neither report provides an objective and systematic review of evidence accumulated to date. Meta-analysis, the basis for this study, is well-suited for addressing these limitations because it provides a quantitative synthesis of study information and an objective review of research. Findings of a meta-analysis have implications for colleges and universities that prepare teachers, state agencies that regulate teacher certification, and local school districts that hire teachers.

Overview of Teacher Certification

The teacher certification process refers to the academic preparation and competency testing required of public school teachers. All prospective public school teachers must attend a state approved teacher education program in order to obtain certification.

Historically, colleges of education have been the primary source of elementary and secondary school teachers. Commonly referred to as "traditional teacher certification," prospective teachers complete a teacher education program at a college or university that had been approved by the state licensing authority (Feistritzer, 1999). The specific requirements of traditional teacher preparation programs differ across states. Undergraduate teaching candidates in some states are required to major in education but in others, prospective candidates must major in the content area in which they plan to teach. In general, traditional teacher preparation programs require prospective teachers to complete a specified number of credit hours of coursework in education and in the content area of the intended teaching subject.

Prior to the 1980's teacher certification was available primarily through undergraduate teacher preparation programs administered by colleges and universities. In response to a growing teacher shortage, several alternate routes to certification were developed to attract college graduates into the profession (Feistritzer, 2001;Stoddardt & Floden, 1995). Colleges of education and universities began offering post-baccalaureate routes to certification to accommodate individuals holding undergraduate degrees. Similarly, local school districts began to provide what has come to be known as "alternative" certification. In contrast to traditional certification, alternative certification focuses on compressed and intensive field-based training and instruction in preparation for the classroom (Feistritzer, 2001). In general, alternative methods of certification tend to produce teachers for specific teaching positions (Feistritzer, 2001), while traditional certification places more emphasis on imparting pedagogy to prospective teachers (Stoddart & Floden, 1995).

Currently, prospective teachers can obtain certification as undergraduates through traditional certification or as degree holders through post-baccalaureate or alternative certification programs. According to the National Council for Education Information (NCEI), each state prescribes a minimum and maximum number of semester credit hours in education and in field experience hours for each type of program (Feistritzer, 1999b). Upon completion of a teacher preparation program, prospective teachers in most states must demonstrate competency by passing a state administered examination. One portion of the examination tests content area knowledge and the other, pedagogical knowledge. A passing score on both portions is required for certification.

Despite differences in state requirements for certification, teachers in most states must: (a) have at least a bachelor's degree; (b) complete an approved, accredited education program; and (c) pass either a state test or other exam such as the National Teacher Exam (NTE). As a means of addressing teacher shortages, many states waive full state certification requirements on an emergency, temporary or provisional basis for individuals who do not meet some or all of the requirements. Terminology varies greatly from state to state but individuals teaching with emergency or temporary waivers and permits typically lack full state certification. Typically granted on a temporary basis, the expectation is that the teacher will obtain the necessary credentials to become fully certified or will eventually be replaced by a regularly certified instructor (Roth & Swail, 2000).

Irrespective of the route, full state certification signifies that prospective teachers have met the coursework, field experience and competency requirements prescribed by the state. Certification is therefore a regulatory approach to teacher quality predicated on the notion that such training and preparation yields teachers who are effective in producing positive student outcomes. Recently, the training and preparation deemed essential to student outcomes has been challenged.

National Educational Policy Organizations

Two national educational policy organizations have brought teacher certification to the fore. The National Commission on Teaching and America's Future and The Abell Foundation represent rival perspectives on the question of whether certification is an

effective means of regulating teacher quality. The philosophy of each organization is discussed below.

The National Commission on Teaching and America's Future

The National Commission on Teaching and America's Future (NCTAF) is the principal proponent for the formal preparation of teachers. The NCTAF's former director, Linda Darling-Hammond, is the leading spokesperson on teacher preparation and on the value of certification in regulating teacher quality (Darling-Hammond, 1996, 1997, 1999, 2000a, 2000b, 2002; Darling-Hammond & Ball, 1997; Darling-Hammond, Berry & Thoreson, 2001). The organization has been influential in framing policy discussion of teacher training and quality at the federal and state level.

According to the NCTAF, certification ensures that teachers have the requisite knowledge and skills to improve student achievement. "Certification and licensure ensure that children get teachers who are competent in subject matter and the knowledge of how to teach. Both are critical for improving student achievement" (Focus on Teaching Quality, 2001). The NCTAF regards uncertified teachers as unqualified because they lack formal preparation and experience in teaching theory and methods.

Currently, the majority of teachers obtain certification through traditional teacher preparation programs. Accordingly, the NCTAF is a strong advocate for college and university teacher preparation programs that focus on coursework in pedagogy or teaching theory and methods. The NCTAF contends that this type of training is vital to

positive student outcomes. Similarly, without these skills and knowledge, prospective teachers are ill prepared for improving student performance.

The NCTAF favors reforms in teacher preparation (Darling-Hammond, 2000) that include:

1. requiring school districts to hire qualified teachers (p. 24)
2. an increase in coursework and pre-service training requirements before prospective teachers can enter the classroom
3. five-year teacher preparation programs instead of the conventional four-year undergraduate degree (p. 21)
4. all teacher training programs should be accredited by the National Council on the Accreditation of Teacher Education (NCATE), the main accrediting body for schools of teacher education.

The Abell Foundation

The Abell Foundation opposes the current structure of teacher certification (Walsh, 2001). Their philosophy is based on the notion that the requirements for teacher certification mandated by states do not guarantee teacher quality. The Abell Foundation believes that the certification process merely ensures that prospective teachers have fulfilled a prescribed set of coursework. However, the organization contends that fulfillment of these requirements is not sufficient evidence to proclaim that certified teachers are more effective than uncertified teachers. “Acting as a very crude proxy for teacher quality, the process is incapable of distinguishing between significant, justifiable

reasons for denying uncertified candidates access to the profession and insignificant, unjustifiable reasons" (Walsh, 2001, p. 4).

Teacher quality, as advocated by The Abell Foundation, should be based on a certification process that emphasizes the importance of strong academic backgrounds and credentials including high scores on tests of verbal ability. This organization advocates reforms in teacher certification and teacher preparation. The reforms discussed in Walsh (2001) include:

1. Coursework requirements for certification mandated by colleges of education and universities should be eliminated.
2. The requirement for certification should consist of a bachelor's degree and a passing score on a certification exam.
3. The certification examination should assess the verbal ability and subject matter knowledge of prospective teachers.
4. In place of state control of certification, local school districts should regulate teacher certification.

The Abell Foundation contends that the current requirements of teacher preparation programs set by states limit the entry of qualified individuals into teaching and contributes to teacher shortages. The coursework needed for certification translates into additional time and cost, the burden of which discourages interested individuals from pursuing teaching (Walsh, 2001).

Educational Policy Reports on Teacher Certification

The National Commission on Teaching and America's Future and The Abell Foundation have authored reports that elaborate their positions on certification and offer supporting evidence in the form of research studies. Each report illustrates the perspective of its respective organization and is summarized below.

The National Commission on Teaching for America's Future

As head of the NCTAF, Darling-Hammond authored several reports that examine the credentials and qualifications of teachers and their effect on student achievement. The report, "Teacher Quality and Student Achievement: A Review of State Policy Evidence," (Darling- Hammond, 2000a) is a study of how teacher qualifications and other school inputs are related to student achievement across the 50 states. The study also includes a narrative review of research evidence that supports the relationship between teacher qualifications and student achievement. The author concludes that teacher quality variables such as certification status are positively associated with student achievement. Policy recommendations for states interested in improving student achievement point to the importance of regulating the preparation and credentials of teachers.

The Abell Foundation

The Abell Foundation's report, "Teacher Certification Reconsidered: Stumbling for Quality," (Walsh, 2001) has several components. First, the Abell report provides a

narrative review of research on the relationship between various components of teacher preparation and qualifications and student achievement. One portion of the review consists of research studies that support the philosophy and policies of The Abell Foundation while the other portion presents study findings that contradict the conclusions made by the NCTAF.

Second, The Abell Foundation report reviews the research on teacher qualifications presented in the NCTAF report and critiques the studies in terms of their methodological weaknesses. According to The Abell Foundation, the research cited in the NCTAF report consists of studies that are not scientifically or statistically rigorous. The main objections to the report are:

1. Research studies that do not help the case for certification are overlooked.
2. Imprecise or inaccurate evidence is cited in support of certification. The lack of evidence to support certification is concealed by padding analyses with citations that upon investigation provide no support for certification.
3. The case for certification often relies on research that is too old to be reliable or retrievable.
4. The NCTAF makes conclusions about certification without sufficient evidence.
5. There is a reliance on unpublished dissertations and studies that have not been subjected to peer review.
6. Assessment measures have been created to prove the value of certification i.e., no standardized measures of student achievement are used

7. Basic principles of sound statistical analysis are violated, including: (a) lack of control variables; (b) generalizability of sample groups; (c) small sample sizes; and (d) susceptibility to aggregation bias/ecological fallacy.

The Abell Foundation report describes the certification practices in the state of Maryland and proclaims the notion that certification improves student achievement to be unfounded. Finally, the report contends that there is no valid research base that justifies current certification requirements.

A Response to The Abell Foundation Report

The NCTAF responded to The Abell Foundation report with a rejoinder (Darling-Hammond, 2002) that was critical of the quality of research evidence presented in The Abell report. The rejoinder included the following criticisms:

1. Evidence that demonstrates the effectiveness of teacher certification is ignored and key studies are misrepresented.
2. A double standard is employed that ignores methodological shortcomings in studies that support the position of The Abell Foundation.
3. No evidence is given to support its claim that verbal ability and subject matter expertise are major predictors for teacher effectiveness.
4. The report is selective in reporting evidence on how teachers should be prepared beyond subject matter expertise.
5. Policy conclusions made by The Abell Foundation to eliminate current certification practices are illogical.

The Abell Foundation and the NCTAF are at odds over the structure of certification but the source of much of the controversy rests with the quality and relevance of research cited in each report.

Problem Specification

Narrative Reviews

A narrative review should provide a clear objective statement about what is known on a topic by presenting a comprehensive and systematic review of research. As narrative syntheses of research, both of the reports discussed above provide a subjective and limited review of research on the effect of teacher certification on student achievement.

In the case of a politically sensitive topic such as teacher certification, reviews of literature by two policy organizations are more aptly termed *policy reports* because neither review provides an objective account of research evidence accumulated to date. In building a case for or against certification research evidence has been selectively reported to advocate the philosophy and policies of each respective organization. Both reports therefore, offer subjective rather than objective descriptions of research on teacher certification.

As policy reports, neither provides a comprehensive review of research on the effectiveness of teacher certification. The author of any review is charged with conducting an exhaustive search and retrieving all relevant studies. The authors of each policy report have accused the other of excluding relevant studies with contrary

outcomes. It is questionable whether either report offers an exhaustive and comprehensive review of all relevant literature on teacher certification.

A review of research should provide a systematic review of all pertinent evidence. In the rationale for The Abell Foundation report, the author asserts that there has been no effort to systematically examine all the research evidence accumulated on the value of teacher certification (Walsh, 2001, p. 2). However, the structure of a narrative report does not lend itself to a truly systematic review of evidence.

In both reports described above key findings are organized and presented around common study characteristics but essential information is overlooked. First, although both organizations discuss the overall effect of teacher certification on student achievement neither specifically addresses the magnitude of the effect. Second, neither policy report discusses the contextual effects of certification, that is, whether it has a similar effect on student achievement across studies. This would include contexts such as school level (elementary or high school), subject area and student economic status. Third, the reports do not explore whether student and teacher characteristics interact to yield differential outcomes.

As advocates of competing certification policies, neither The Abell Foundation nor the NCTAF provide a thorough and systematic review of research evidence on the impact of teacher certification on student achievement. Both reports are plagued by substantive and methodological issues and neither provides a clear and objective statement on what is known about the effects of teacher certification.

Narrative reviews of research are not the optimal technique for producing an objective and complete account of a topic. “The result is that rather than organizing diverse outcomes into a set of reasonably conclusive findings, the reviews themselves are open to attack for including inappropriate or poorly done studies or for drawing conclusions subjectively” (Light & Pillemer, 1984).

Meta-analysis

Meta-analysis techniques have been designed to overcome the problems associated with narrative reviews (Hedges & Becker, 1986; Hedges & Olkin, 1985; Hunter& Schmidt, 1990). Meta-analysis is a structured research technique that uses quantitative methods to summarize the results of multiple studies. According to Hunter et al. (1982), with meta-analysis it is possible to integrate results from existing studies to reveal patterns of underlying relations, the establishment of which will constitute general principles and cumulative knowledge. It is therefore well-suited to synthesizing the research evidence accumulated on teacher certification.

In contrast to narrative reviews, meta-analysis yields an objective and comprehensive synthesis because the process of summarizing research study findings is systematic and explicit. The criteria that define the population of study findings are specified, search strategies are described and all study characteristics are formally coded. “Thus, the reader can assess the author’s assumptions, procedures, evidence, and conclusions rather than take on faith that the conclusions are valid” (Lipsey & Wilson, 2001, p. 6).

Meta-analysis presents key study findings in a manner that is more structured and sophisticated than narrative reviews. With the use of meta-analysis techniques it is not only possible to determine whether teacher certification has an overall effect on student achievement but also whether the effect is consistent across studies.

Differences in study findings and conclusions may be a function of study characteristics (Hunter & Schmidt, 1990). In meta-analysis, studies are summarized and presented according to differences in contextual characteristics and design. The contextual characteristics include setting characteristics, participant characteristics, research design and analysis techniques. Meta-analysis can identify any potential differences across school levels (elementary or high school), subject areas and student economic status. It is also possible to identify cases in which student and study characteristics interact to yield differential outcomes. Therefore, through a structured examination of the relationship between study findings and study features, meta-analysis is capable of finding effects or relationships that are obscured in narrative syntheses of research (Lipsey & Wilson, 2001).

In summary, meta-analysis is well-suited to addressing the problems encountered with narrative reviews because it provides a precise and systematic means of synthesizing quantitative information available in empirical studies. “For policymakers a rigorous scientific summary of research can be a valuable supplement to political debate” (Light & Pillemer,1984, p.16).

Purpose of the Study

The overall purpose of this study is to review the empirical research evidence accumulated to date on the effect teacher certification on student achievement. To this end, a meta-analysis will be conducted on studies that examine the effect of certified and uncertified teachers on student achievement.

Meta-analysis is a quantitative synthesis of empirical research that provides a systematic and comprehensive examination of study outcomes in relation to study characteristics. In this meta-analysis, the dichotomous or categorical independent variable is teacher certification status and the continuous dependent variable is student achievement.

Research Design

The intent of this inquiry is accomplished using a research design consisting of four sequential phases and twelve research questions. Subsumed within each sequential phase are a unique set of research questions that guide the review of empirical research on teacher certification and student achievement. The purpose and process of each sequential phase is discussed below. Specification of these phases follows the sequential stages model presented in McNamara (1998).

Phase One: Specifying the Meta-analysis Population

The goal of Phase One is to define the meta-analysis population and provide a descriptive analysis of empirical research studies that are appropriate and that contain

sufficient information for inclusion in the inquiry. Following the guidelines in Light & Pillemer (1984), two research questions are used to guide the initial phase of this inquiry.

1. How many studies comprise the meta-analysis population and examine the effect of certification status on student achievement?
2. In the meta-analysis population, how many studies report sufficient quantitative information to be included in the empirical research synthesis?

Answers to these two questions identify the population of studies that are used in the individual quantitative syntheses undertaken in the overall meta-analysis.

Phase Two: Conducting Individual Quantitative Syntheses

In Phase Two, individual quantitative syntheses are conducted for studies that reported results in the areas of mathematics, reading and science. These three quantitative syntheses are based on the statistical models presented in Hedges & Olkin (1985). Specifically, individual effect sizes are calculated for each study and for each subject area. Findings are examined for consistency across the three subject areas. Three research questions are used to guide the individual quantitative syntheses and are described below.

3. What are the findings of the quantitative synthesis conducted on the relationship between teacher certification status and student achievement in mathematics?
4. What are the findings of the quantitative synthesis conducted on the relationship between teacher certification status and student achievement in science?

5. What are the findings of the quantitative synthesis conducted on the relationship between teacher certification status and student achievement in reading?

For each of the three quantitative syntheses specified above, further explanation is gained with the calculation of effect sizes for common study characteristics, or "moderator variables" that include elementary or secondary school level, type of research design, level of analysis and instrumentation. Phase Two provides additional information on whether these findings are consistent within each moderator variable named above. Four research questions guide this portion of Phase Two and are listed below.

6. Are the findings of a meta-analysis conducted on teacher certification status and student achievement likely to differ for studies focused at the elementary and secondary school levels?
7. How similar are the findings of a meta-analysis conducted on teacher certification status and student achievement for studies using different types of research designs?
8. What differences emerge in the relationship between teacher certification status and student achievement when individual or aggregate levels of analysis are used?
9. Are findings of the relationship between teacher certification and student achievement consistent when different instruments are used to measure student achievement?

The quantitative syntheses conducted for each question listed above yield a distribution of effect sizes for the three subject areas named in questions three through five and the four moderator variables identified in questions six through nine.

Phase Three: Identifying Patterns and Trends

Phase Three of the inquiry provides an analysis of the overall patterns and trends uncovered in the individual quantitative syntheses of the three subject areas. Phase Three also examines patterns and trends within each quantitative synthesis of the four moderator variables. Phase Three is guided by the single research question described below.

10. What patterns and trends emerge when results are compared across areas of achievement, school levels, units of analysis, type of research design, and measurement instruments?

Following the narrative and explanatory perspectives outlined in Hunt et al. (1999), this phase reports the findings of each quantitative synthesis produced in Phase Two. Findings of individual syntheses are compared and contrasted and differential outcomes are identified across subject areas and moderator variables.

Phase Four: Specifying Recommendations

Recommendations are an integral part of a meta-analysis. Accordingly, the final phase of the inquiry is a series of recommendations based on the findings from the first three phases. This phase provides recommendations for policy-makers who regulate or

oversee teacher certification requirements. Recommendations are also offered for researchers planning the direction and scope of future research on teacher certification. This phase is guided by the two research questions elaborated below.

11. Given the overall research findings of the meta-analysis, what recommendations can be specified for academic researchers who continue to examine the effect of teacher certification status on student achievement?
12. Given the overall research findings of the meta-analysis, what recommendations can be specified for policy-makers involved in investigating or reforming standards and practices related to teacher certification?

Following the guidelines for meta-analysis, this phase acknowledges the importance of meta-analysis findings for academic researchers (Light & Pillemer, 1984; Cook et al., 2001) and policy makers who are responsible for managerial decisions (Cook, 1994).

Significance of the Inquiry

The benefits of a comprehensive synthesis of research on certification status are relevant for several domains that include educational policy, reviews of literature and future research on the impact of teacher certification.

The meta-analysis findings have fundamental policy implications for The No Child Left Behind Act (U.S. Department of Education [U.S.D.E], 2002). This act is a series of reforms that address current teacher preparation requirements and speak to the notion of quality in the teaching force. Perhaps the most important component of this act is that all teachers in core academic subjects must be “highly qualified” by the end of 2005 - 06

school year. That is, any public elementary school or secondary school teacher must have obtained full state certification and not had certification or licensure requirements waived on an emergency temporary or provisional basis (p. 4).

The requirement that all teachers hold full state certification coincides with reforms in teacher preparation that call for teacher preparation programs to emphasize rigorous academic content. The requirement that all teachers be certified is likely to have an impact on teacher preparation programs and the supply of certified teachers. The results of this inquiry are designed to provide new evidence on whether certified teachers are more effective than uncertified teachers in improving student achievement. Moreover, the findings of this inquiry identify the conditions and circumstances in which certification has the greatest impact on student achievement.

The second benefit of the inquiry is that the findings of a meta-analysis provide a synthesis of research on certification that has not yet been achieved with narrative reviews. Based on study-level analysis, each quantitative synthesis in the meta-analysis yields information on the effect of certification for three subject areas and the moderator variables that may produce differential outcomes. Meta-analysis provides information that enhances the generalizability of outcomes and yields findings that cannot be uncovered with individual studies (Light & Pillemer, 1984). Such information serves as a truly systematic review of the effect of certification and of the study characteristics that may account for differential levels of student achievement. The findings serve as an objective account of the current state of literature and research on teacher certification. The evidence generated by the inquiry will hopefully shed light on the topic and help

quell the debate between The Abell Foundation and the National Commission on Teaching and America's Future.

The third benefit of the inquiry is that the findings and conclusions of a meta-analysis can shape the design of future research on teacher certification. The findings of the inquiry serve as a benchmark of the status of research on teacher certification and point to areas in need of further investigation. For example, the degree to which student achievement in each subject area is affected by moderator variables suggests the need for more sophisticated research designs.

Organization of the Dissertation

The dissertation is organized into eight chapters, each chapter reflecting an essential component of the inquiry.

Chapter I provides specifications for the purpose of the inquiry, the research questions and the research design which includes four sequential phases.

Chapter II provides the findings for Phase One of the inquiry that defines the meta-analysis population and the research studies that comprise this population.

Chapter III presents the findings of Phase Two where the dependent variable of the quantitative synthesis is mathematics achievement.

Chapter IV presents the findings of Phase Two where the dependent variable of the quantitative synthesis is science achievement.

Chapter V presents the findings of Phase Two where the dependent variable of the quantitative synthesis is reading achievement.

Chapter VI presents the findings of Phase Three that examines the patterns and trends uncovered across the three subject areas.

Chapter VII is based on Phase Four of the inquiry and offers recommendations for academic researchers planning and designing research studies on the topic and policymakers who implement certification practices.

Chapter VIII is used to summarize the findings for each of the four sequential phases and present conclusions for the complete scope of this inquiry.

CHAPTER II

THE META-ANALYSIS POPULATION

This chapter documents the findings for the first phase of the inquiry. This phase is used to specify the meta-analysis population. The chapter is organized into three sections. The first section defines the criteria used to select studies. The second section documents the four search procedures used to locate the individual studies that comprise the meta-analysis population. The final section describes the detailed characteristics for this meta-analysis population.

Defining the Meta-analysis Population

In general, studies that investigated the relationship between teacher certification and student achievement were designated as eligible for meta-analysis. The principal criteria for inclusion in the meta-analysis included (a) a dichotomous or categorical independent variable that focused on the certification status of teachers (certified vs. un-certified), and (b) a dependent variable that provides a measure of standardized student achievement for one or more subject areas.

Studies were further reviewed against six additional criteria. The first two criteria are based on the criticisms levied by The Abell Foundation against the quality of research reported by the National Commission on Teaching and America's Future. The remaining four criteria correspond to basic study characteristics that address the focus of this inquiry. The criteria are as follows:

1. The study was published no earlier than 1980.
2. The study was published in a refereed journal.
3. The dependent variable is a measure of standardized student achievement for one or more subject areas including mathematics, science or reading.
4. The study was conducted with public school students and teachers.
5. The study was conducted in academic subjects such as mathematics, science and reading.
6. The study was conducted in the United States.

Search Procedures

Meta-analysis takes advantage of several search strategies to locate studies that meet the criteria that define the meta-analysis population. Four different search strategies were used to obtain studies for the analysis. Studies produced by each search strategy were reviewed against the criteria described above. The four search strategies and the yield of studies rendered by each strategy are described below.

Strategy One: National Reports

The reference lists of the two national reports named above were reviewed to identify relevant studies. Many studies cited in "Teacher Certification Reconsidered: Stumbling for Quality," (Walsh, 2001) and "Teacher Quality and Student Achievement: A Review of State Policy Evidence," (Darling-Hammond, 2000a) did not meet the criteria specified for the meta-analysis. Studies were excluded for being a dissertation (Laczko-Kerr,

2002), an unpublished paper (New York City Board of Education, 2000), or not using student achievement as a dependent variable (Denton & Lacina, 1982). Additional reasons for exclusion included the use of an independent variable other than teacher certification status (Erekson & Barr, 1985; Hanson & Feldhusen, 1994). The majority of studies failed to meet more than one selection criteria.

The search of references in both national reports yielded one study that met all criteria of the meta-analysis population (Hawk, Coble & Swanson, 1985).

Strategy Two: Computer Searches

An extensive systematic search was conducted to locate studies that had explored the effect of teacher certification on student achievement. Computer searches for listings of published studies were carried out in the Educational Research Information Center (ERIC), Econlit, PsychLit, Social Citations Index and the Wilson Index.

Key words and phrases were used to search for relevant studies. The search terms used in the computer search strategy are described in Table 2.1. This table presents thirty search terms in three categories: (a) certification and teachers; (b) students; and (c) general education. Search terms in each category were used alone and in combination to yield relevant studies.

Studies with any search term listed above in the title or abstract were retrieved, reviewed for relevance and evaluated against the criteria for inclusion in the meta-analysis population. Searches utilizing keywords named above produced descriptive analyses of current certification practices (Ingersoll, 1996) or policy reports on

Table 2.1
Search Terms Used to Generate Studies on Teacher Certification and Student Achievement

Certification and Teachers	Students	General Education
Alternative teacher certification	Academic achievement	Comparative analysis
Knowledge base for teaching	Student achievement	Educational certificates
Professional certification	Student characteristics	Educational quality
Professional licensing	Mathematics achievement	Elementary education
Teacher background	Reading achievement	Emergency permits
Teacher certification	Science achievement	Emergency programs
Teacher characteristics		Secondary education
Teacher competencies		
Teacher credentials		
Teacher education		
Teacher effectiveness		
Teacher evaluation		
Teacher licensure		
Teacher quality		
Teacher qualifications		
Teacher supply and demand		
Teaching skills		

certification (Sullivan, 2001; Evertson et al, 1985). Use of the term, comparative analysis, was particularly effective in generating studies that compared certified and uncertified teachers. The computer search of databases yielded one study that met all criteria for inclusion in the analysis (Goldhaber & Brewer, 2000).

An additional internet search of online refereed journals was conducted. The search yielded one additional study that met all criteria (Laczko-Kerr & Berliner, 2002).

Strategy Three: Search of Bibliographies

The bibliographies of the three studies produced by the two search strategies described above were reviewed to identify additional studies that met the criteria of the meta-analysis population. This method provided references for the three studies obtained with previous strategies but did not generate any additional studies.

Strategy Four: Name Search

A name search of authors of the three studies produced by the previous search strategies was conducted to identify additional studies. No additional studies conducted by the three authors met the criteria of the meta-analysis population.

The four search strategies described above yielded three studies that utilized individual level data and a dichotomous or categorical independent variable, namely, teacher certification. These search strategies also produced two studies that utilized a continuous independent variable in lieu of a dichotomous certification variable. These two studies relied on teacher and student data aggregated at either the state level

(Darling-Hammond, 2000a) or the school level (Fetler, 1999) in their analysis of teacher certification.

Excluded Studies

The four search procedures described above generated references for many articles and studies on teacher certification and student achievement. Some studies met the following two principal criteria for inclusion in the meta-analysis: (a) a dichotomous or categorical independent variable that focused on the certification status of teachers (e.g., certified vs. un-certified); and (b) a dependent variable that provides a measure of standardized student achievement for one or more subject areas.

However, many studies did not meet all criteria for inclusion in the meta-analysis. The major characteristics of some excluded studies are described below.

1. The study was presented as a paper at a conference and did not appear in a refereed journal (Peck, 1989; Harpole & Hardley, 1986; Franklin, & Crone, 1992).
2. The study was a dissertation (Gallagher, 2002; Laczko-Kerr, 2002; Ponders, 2001; Isbell, 2000; Huguenard, 1992).
3. The study used data that was identical to the data used in a selected study (Goldhaber & Brewer, 1996, 1997, 1999a, 1999b, 2000; Brewer & Goldhaber, 1998).
4. The study was conducted with private school students and teachers.

5. The study was conducted in non-academic subject areas such as music (Zirkle, 1998).
6. The study was conducted in countries other than the U.S. (Lockheed, 1989; Biniaminov, 1983).

Characteristics of the Meta-analysis Population

A total of three studies met the criteria specified above and reported sufficient quantitative information to be included in the analysis. The characteristics of these three studies are described in Table 2.2. The table presents the characteristics of the study population according to following study features: (a) subject area, (b) target population, (c) instrument used to measure student achievement, (d) type of teacher certification, (e) level of analysis, and (f) research design.

Two studies that did not meet the criteria specified for the analysis are also included. Both studies utilize an aggregate unit of analysis representing the proportion of teachers holding certain certification credentials. The characteristics of these three studies are described in Table 2.3.

The rationale for integrating these two studies in the analysis is threefold. First, Study Four is part of the report by The National Commission on Teaching and America's Future (Darling-Hammond, 2000a). Second, as the former director of the NCTAF and the author of Study Four, Linda Darling-Hammond has authored many publications on the value of certification (Darling-Hammond, 1996, 1997, 1999a, 1999b, 2000a, 2000b, 2002; Darling-Hammond & Ball, 1997; Darling-Hammond, Berry & Thoreson, 2001).

Finally, Studies Four and Five are recent studies that present correlational evidence for the effect of teacher certification. Therefore, for the reasons outlined above, these studies are included in the analysis.

A review of tables 2.2 and 2.3 reveals that the size of the meta-analysis population is limited to five studies. This finding is notable in light of the information presented in the two national reports on teacher certification. In each report, The Abell Foundation (Walsh, 2001) and The National Commission on Teaching and America's Future (Darling-Hammond, 2000a) elaborate their respective positions on certification and offer supporting evidence in the form of research studies. Each report included a narrative review of research evidence that either supports or challenges the purported relationship between teacher qualifications and student achievement.

Both national reports review aspects of teacher certification that are beyond the scope of this inquiry. However, when studies that explore teacher certification and student achievement are reviewed against the criteria elaborated above, only five studies are eligible for consideration. This discovery constitutes the first major finding of the inquiry.

Table 2.2

Characteristics of Studies That Yield Mean Difference Effect Size Estimates

Study	Author/Year	Subject Area(s)	Target Population	Instrument	Type of Teacher Certification	Level of Analysis	Research Design
Study One	Goldhaber & Brewer (2000)	Mathematics and Science	12th grade students	National Educational longitudinal Survey.	Standard certification Probationary certification Emergency certification Private school certification No certification in subject area.	Individual	Regression model
Study Two	Hawk, Coble & Swanson (1985)	General Mathematics and Algebra	Students in grades 6 through 12	Stanford Achievement Test (SAT 9)	Teachers certified in mathematics or outside mathematics.	Individual	Pre-post test design
Study Three	Laczko-Kerr & Berliner (2002)	Reading Mathematics and Language Arts.	Multiple grades	Stanford Achievement Test (SAT 9)	Certified Under certified Emergency certification Temporary certification Provisional certification	Class	Matched pair design

Table 2.3

Characteristics of Studies That Yield Correlational Effect Size Estimates

Study	Author/ Year	Subject Area(s)	Target Population	Instrument	Type of Teacher Certification	Level of Analysis	Research Design
Study Four	Darling-Hammond (2000a)	Mathematics and Reading	4th and 8th grade students 4th grade students	State average achievement scores from the National Assessment of Educational progress (NAEP)	Percent of fully certified teachers Percent of fully certified new teachers Percent of uncertified teachers Percent of newly hired uncertified teachers	State	Correlation and regression
Study Five	Fetler (1999)	Mathematics	9th, 10th and 11th grade students	Average scores from the Stanford Achievement Test (SAT 9)	Percent of teachers with emergency certificates	School	Correlation

CHAPTER III

FINDINGS FOR MATHEMATICS ACHIEVEMENT

This chapter presents the findings for the research synthesis on mathematics achievement. This synthesis was undertaken in the second phase of this inquiry. The chapter is organized into six sections. The first five sections deal with the contribution of each of the five studies to the synthesis of mathematics achievement. The final section details the trends of these studies.

Section One

Section one documents the characteristics and contribution of Study One (Goldhaber & Brewer, 2000) to the synthesis of mathematics achievement. The study explores whether the type of certification held by a teacher influences student achievement in mathematics. The study characteristics for Study One are presented in Table 3.1.

Independent Variable

One independent variable was used to investigate the effect of teacher certification on student achievement. The four levels of the independent variable are defined as follows:

1. Standard certification refers to teachers who hold a standard or regular certificate. Such teachers are regarded as fully certified and have completed all requirements designated by the state.

2. Probationary certification refers to teachers who have satisfied all requirements except the completion of a probationary period.
3. Emergency permits are held by teachers who must complete additional coursework before they can be issued a standard certificate.
4. The "no certification" category includes teachers who are either certified or do not fall into any of the above categories. Teachers designated as "not certified" may be certified, but not in the area of mathematics.

Each type of certification listed above refers to certification in the area of mathematics.

Table 3.1
Characteristics of Study One for Mathematics Achievement

School Level	Dependent Variable	Independent Variable (Certification Status)	Research Design
Secondary (12^{th} grade students)	Scores from National Educational Longitudinal Survey.	Standard certification Probationary certification Emergency certification No certification in subject area.	Regression model

Dependent Variable

The continuous dependent variable utilized in the study is individual student achievement scores taken from the National Educational Longitudinal Survey (NELS). The dependent variable is the gain in mathematics achievement scores from tenth to twelfth grade.

Table 3.2 presents the input data associated with each of the following types of certification: (a) standard certification, (b) probationary certification, (c) emergency certification, and (d) no certification. The effect of certification on achievement is examined by comparing teachers with standard certificates to teachers with either probationary, emergency or no certification.

Table 3.2
Study One Input Data for Mathematics Achievement

Type of Certification	Gain from Tenth Grade to Twelfth Grade		
	M	SD	N
Standard Certification in Subject	5.05	5.36	3179
Probationary Certification in Subject	6.51	3.54	24
Emergency Certification in Subject	5.80	5.12	49
No certification in Subject	3.59	4.68	77

M = average mathematics achievement score
SD = standard deviation of average mathematics achievement score
N = number of observations

Table 3.3 presents the effect size indicators for contrasts between standard certification and the remaining three certification categories. A detailed description of the purpose of the study, the research design, input data and calculations for effect size indicators are contained in Appendix A.

Table 3.3
Study One Effect Size Indicators for Mathematics Achievement

Certification Status	Effect Size Indicators					
	S_d	d	v	M.E.	CI_{95} Lower	CI_{95} Upper
Standard Certification in Subject versus:						
Probationary Certification in Subject	5.35	-0.273	0.042	0.402	-0.674	0.129
Emergency Certification in Subject	5.36	-0.140	0.021	0.282	-0.422	0.142
No certification in Subject	5.35	0.273*	0.013	0.226	0.047	0.499

* $p < 0.05$
S_d = pooled standard deviation
d = adjusted effect size
v = effect size variance
M.E. = margin of error
CI_{95} = 95% confidence interval for the adjusted effect size estimate

Effect Size Estimates

Descriptive statistics for teachers with standard certification were compared to teachers with probationary certification, emergency certification and no certification in mathematics. A discussion of the effect size estimates associated with each comparison is presented below.

Standard Certification and Probationary Certification

A comparison of probationary certification and standard certification yielded an effect size estimate of $d = -0.273$. Inspection of the confidence interval reveals that this effect size estimate is not significant at the $p < 0.05$ level. Therefore, students taught by teachers with either type of certification exhibited equivalent levels of achievement in mathematics.

Standard Certification and Emergency Certification

A comparison of emergency certification and standard certification yielded an effect size estimate of $d = -0.140$. Inspection of the confidence interval reveals that this effect size estimate is not significant at the $p < 0.05$ level. Therefore, students taught by teachers with either type of certification exhibited equivalent levels of achievement.

Standard Certification and No Certification

A comparison of emergency certification and standard certification yielded an effect size estimate of d = 0.273. Inspection of the confidence interval reveals that this effect size estimate is significant at the $p < 0.05$ level.

Students taught by teachers with no certification exhibit lower average gain scores than students of teachers with standard certification. Fifty percent of students taught by teachers with standard certification exhibit gain scores above the mean (M = 5.05) but only 39 percent of students taught by teachers with no certification exhibit gain scores above this value.

Summary of Findings

Of the three mean difference effect size estimates generated from Study One, only the comparison of emergency certification and standard certification was significant at the $p < 0.05$ level. Students taught by teachers without certification exhibit significantly smaller gains in achievement than students of teachers with standard certification. Students taught by teachers with emergency, probationary or standard certification exhibited equivalent levels of achievement.

Section Two

This section documents the contribution of Study Two (Hawk, Coble and Swanson, 1985) to the synthesis of mathematics achievement. Study Two compares the achievement of students in two mathematics courses: (a) general mathematics (middle

school), and (b) algebra (high school). Both courses were taught by teachers certified in mathematics and teachers certified out-of-field. For each course, the achievement scores of students taught by teachers certified in mathematics were compared to teachers certified in an outside field.

Independent Variable

The dichotomous or categorical independent variable utilized in the study includes teachers holding either: (a) certification in mathematics, or (b) certification in a field other than mathematics. The study involved eighteen teaches from each of these two groups.

Dependent Variable

In general mathematics and algebra, the dependent variable was individual student achievement scores. Table 3.4 presents the characteristics of each course examined in the study. The upper portion of the table presents the characteristics of the first course, general mathematics and the lower portion presents the second course, algebra. Table 3.5 presents the input data for each mathematics course and the corresponding effect size indicators. A detailed description of the purpose of the study, the research design, input data for each course and calculations for effect size indicators are contained in Appendix B.

Table 3.4
Characteristics of Study Two for Mathematics Achievement

School Level	Dependent Variable	Independent Variable (Certification Status)	Research Design
Middle School	General Mathematics: Scores from the Stanford Achievement Test	Teachers certified in the field of mathematics Teachers certified outside the field of mathematics.	Pretest Post-test Design
High School	Algebra: Scores from the Stanford Test of Academic Skills	Teachers certified in the field of mathematics Teachers certified outside the field of mathematics.	Pretest Post-test Design

Table 3.5

Study Two Effect Size Indicators for Mathematics Achievement

		Pretest		Posttest			Effect Size Indicators					
		M	SD	M	SD	N	S_d	d	v	M.E.	CI_{95}	
											Lower	Upper
General Mathematics	In-Field	23.93	8.69	27.14	8.75	286	8.46	0.373*	0.007	0.166	0.207	0.538
	Out of Field	22.00	7.87	23.98	8.14	283						
Algebra	In-Field	20.21	6.25	25.54	6.75	28	6.74	0.170	0.098	0.607	- 0.440	1.21
	Out of Field	23.25	6.12	24.37	6.72	16						

* $p < 0.05$
M = average mathematics achievement score
SD = standard deviation of average mathematics achievement score
N = number of observations
S_d = pooled standard deviation
d = adjusted effect size
v = effect size variance
M.E. = margin of error
CI_{95} = 95% confidence interval for the adjusted effect size estimate

Effect Size Estimates

The input data yielded two effect sizes, one for general mathematics and the other for algebra. A discussion of the effect sizes associated with each course is presented below.

General Mathematics

A comparison of teachers certified in mathematics with those certified out-of-field yielded an effect size estimate of $d = 0.373$. Inspection of the confidence interval reveals that this effect size estimate is significant at the $p < 0.05$ level.

The direction of the effect size suggests that achievement scores are on average higher for students of teachers certified in mathematics than teachers certified out-of-field. The mean achievement score of students taught by teachers certified out-of-field indicates that 50 percent score above the mean ($M = 23.98$). Of the students taught by teachers certified in mathematics, 64 percent score above this value. Therefore, compared to teachers who are certified out-of-field, the effect of certified mathematics teachers on student achievement is that an additional 14 percent of the students score above this value.

Algebra

A comparison of teachers certified in mathematics with those certified out-of-field yielded an effect size estimate of $d = 0.170$. Inspection of the confidence interval reveals that this effect size estimate is not significant at the $p < 0.05$ level. Therefore, average achievement in algebra for students taught by either category of teaches is similar.

Summary of Findings

Of the two mean difference effect size estimates generated from Study Two, one was significant. This finding suggests that in general mathematics courses, students taught by teachers certified in mathematics exhibit higher average achievement scores than students of teachers certified out-of-field. The finding for algebra courses was not significant and suggests that average achievement is equivalent for students taught by either category of teachers.

Section Three

Section three documents the characteristics and contribution of Study Three (Laczko-Kerr & Berliner, 2002) to the synthesis of mathematics achievement. Based on scores in mathematics from two years of data, this study compares class-level achievement of students by matching pairs of certified and under-certified teachers from similar schools and districts. Table 3.6 presents the study characteristics for each year of data.

Independent Variable

The dichotomous independent variable refers to teachers who are either: (a) fully certified, or (b) under-certified. The initial independent variable utilized in Study Three consisted of teachers who had one of the following types of certification: (a) full state certification, (b) emergency certification, (c) temporary certification, or (d) provisional certification. The latter three groups were combined to form one group of under-certified

Table 3.6
Characteristics of Study Three for Mathematics Achievement

School Level	Dependent Variable	Independent Variable (Certification Status)	Research Design
Data Set One 1998 - 1999			
Grades 3 – 8	Class means for Stanford Achievement Test	28 pairs of teachers of individual teachers that fall into one of the following categories: Under-certified Full state certification	Ex-post-facto matched pair
Data Set Two 1999 - 2000			
Grades 3 – 8	Class means for Stanford Achievement Test	87 pairs of teachers of individual teachers that fall into one of the following categories: Under-certified Full state certification	Ex-post-facto matched pair

teachers after results of a one-way analysis of variance (ANOVA) conducted by the authors revealed that mean scores for these three groups were not statistically different.

Dependent Variable

The study utilized two separate years of student test scores in mathematics. Individual level student scores were aggregated at the class level to yield an average achievement score for each teacher involved in the study. The raw data therefore consisted of class-level means reported in normal curve equivalent scores (NCE). The continuous dependent variable herein refers to class-level mean achievement scores in grades three through eight for two separate years.

A detailed description of the purpose of the study, the research design, input data for each year and calculations for effect size indicators are contained in Appendix C.

Effect Size Estimates

The input data for this study yielded an effect size for each year of data. Table 3.7 presents input data for each year and the associated effect size indicators. A discussion of the effect sizes associated with each year of data is presented below.

Table 3.7

Study Three Effect Size Indicators for Mathematics Achievement

	Certified Teachers		Under-Certified Teachers			Effect Size Indicators					
	M	SD	M	SD	N	S_d	d	v	M.E.	CI_{95}	
										Lower	Upper
Dataset One 1998 – 1999	38.80	8.77	35.82	7.32	28	8.23	0.357	0.073	0.528	- 0.171	0.885
Dataset Two 1999 - 2000	39.75	9.52	35.22	9.77	87	9.70	0.465*	0.024	0.301	0.164	0.766

* $p < 0.05$
M = average mathematics achievement score
SD = standard deviation of average mathematics achievement score
N = number of observations
S_d = pooled standard deviation
d = adjusted effect size
v = effect size variance
M.E. = margin of error
CI_{95} = 95% confidence interval for the adjusted effect size estimate

***Data Set One**: 1998 - 1999*

A comparison of teachers fully certified in mathematics with under-certified teachers yielded an effect size estimate of d = 0.357. Inspection of the confidence interval reveals that this effect size estimate is not significant at the $p < 0.05$ level. Therefore, average achievement in mathematics for students taught by either category of teaches is equivalent.

***Data Set Two**: 1999 - 2000*

A comparison of teachers fully certified in mathematics with under-certified teachers yielded an effect size estimate of d = 0.465. Inspection of the confidence interval reveals that this effect size estimate is significant at the $p < 0.05$ level.

The direction of the effect size for data set two indicates that on average, students of teachers with full state certification outperform their counterparts. Half the classes taught by under-certified teachers scored above the mean (M = 35.22) while 68 percent of classes taught by fully certified teachers scored above this value. Therefore, certification in mathematics yields an 18 percent increase in the number of classes that score above a mean of 35.22.

Combined Estimator

In Study Three, each year of data is based upon a single population that shares the same effect size parameter. It is therefore possible to integrate the effect size estimate for each year of data into a combined estimator. The estimate represents the overall effect of

certification on student achievement for the two years. Table 3.8 presents the combined effect size estimator, the combined variance estimate and the 95 percent confidence interval. The calculations for these estimates are contained in Appendix C. The combined estimator is significant at the $p<0.05$ level, and indicates that on average, students of teachers with full state certification in mathematics outperform students of under-certified teachers.

Summary of Findings

Of the two mean difference effect size estimates generated from Study Three, one was significant. This finding indicates that students of teachers who are fully certified in mathematics outperform students of under-certified teachers. In the case of the insignificant finding, students of fully certified and under-certified teachers exhibit equivalent levels of achievement.

Table 3.8
Study Three Combined Effect Size Indicators for Mathematics Achievement

Combined Effect Size Indicators				
d.	v.	M.E.	CI_{95} for d.	
			Lower	Upper
0.44*	0.132	0.26	0.18	0.70

* $p < 0.05$
d. = adjusted combined effect size estimate
v. = combined effect size variance
M.E. = margin of error for a 95% confidence interval

Section Four

Section Four documents the characteristics and contribution of Study Four (Darling-Hammond, 2000a) to the synthesis of mathematics achievement. This study investigates whether the percentage of teachers with full state certification is associated with state-level National Assessment of Educational Progress (NAEP) student achievement scores.

Three separate years of state-level data representing 44 states were used in the study. The analysis focused on fourth grade mathematics data from 1992 and 1996 and eighth grade mathematics data from 1990 and 1996. Therefore, state-level data are organized into four datasets that include: (a) grade four data from 1992, (b) grade four data from 1996, (c) grade eight data from 1990 and (d) grade eight data from 1996. Table 3.9 presents the study characteristics for each grade.

Independent Variable

For each of the four datasets, two continuous independent variables were used to investigate the role of teacher certification on student achievement. The two independent variables are defined as follows:

1. "Fully certified includes teachers with standard or regular certification and new teachers on probationary certificates who have completed all requirements for a license except for the completion of the probationary period (usually two or three years of beginning teaching." (Darling-Hammond, 2000a, pg 25)

Table 3.9
Characteristics of Study Four for Mathematics Achievement

Research Design	Level	Continuous Independent Variable (Certification Status)	Dependent Variable
Correlation	Grade 4 1990 and 1996	Percentage of teachers who are: Fully certified Less-than-fully certified	State-level NAEP achievement scores
	Grade 8 1992 and 1996	Percentage of teachers who are: Fully certified Less-than-fully certified	State-level NAEP achievement scores

2. "Less-than-fully certified includes teachers with no certificate and those with provisional, temporary, or emergency certification." (Darling-Hammond, 2000a, pg 25)

Dependent Variable

For each of the four datasets, the continuous dependent variable is state-level NAEP mean achievement scores in mathematics.

Control Variable

For each state, the control variable, poverty, is defined as the percentage of students with family incomes below the poverty line. The correlation coefficients associated with each dataset represent the partial correlation between the independent and dependent variable with the effect of poverty removed from both. A detailed description of the purpose of the study, research design and definition of terms are contained in Appendix D.

Effect Size Estimates

Table 3.10 presents the input data for grades four and eight. The partial correlation of the two teacher certification variables and mean NAEP achievement scores yielded four coefficients for each grade.

Grade Four

Based on data from 44 states, the correlation of the percentage of fully certified teachers with mean NAEP scores yielded a significant value of 0.36 for 1992. An increase of one standard deviation in the percentage of fully certified teachers

Table 3.10
Study Four Input Data for Mathematics Achievement

Data set		Partial Correlations between Teacher Certification Variables and Mean Student NAEP Achievement		
		Percentage of Fully Certified Teachers	Percentage of Less-than-fully Certified Teachers	Control Variable
Grade 4				
	1992	0.36*	-0.36*	Student Poverty
	1996	0.20	-0.23	
Grade 8				
	1990	0.38*	-0.33*	Student Poverty
	1996	0.28	-0.28	

* $p < .05$

corresponds to an increase in mean achievement of 0.36 of a standard deviation. The correlation for the 1996 data was not significant, signifying no association between the percentage of fully certified teachers and mean achievement.

The correlation of the percentage of less-than-fully certified teachers with mean NAEP scores yielded a significant value of -0.36 for 1992. An increase of one standard deviation in the percentage of less-than-fully certified teachers corresponds to a decrease in mean student achievement of 0.36 of a standard deviation. The correlation for the 1996 data was not significant, signifying no association between the percentage of less-than-fully certified teachers and mean achievement.

Grade Eight

The correlation of the percentage of fully certified teachers with mean NAEP scores yielded a significant value of 0.38 for 1990. A one standard deviation increase in the percentage of fully certified teachers translates into an increase in mean achievement of 0.38 of a standard deviation. The correlation for the 1996 data was not significant, signifying no association between the percentage of fully certified teachers and mean achievement.

The correlation of the percentage of less-than-fully certified teachers with mean NAEP scores yielded a significant value of -0.33 for 1990. A one standard deviation increase in the percentage of fully certified teachers translates into a reduction in mean achievement of 0.33 of a standard deviation. The correlation for the 1996 data was not

significant, signifying no association between the percentage of fully certified teachers and mean achievement.

Summary of Findings

The findings for 1992 and 1990 in grades four and eight imply that when poverty is controlled, average student achievement increases with greater proportions of fully certified teachers and smaller proportions of less-than-fully certified teachers. However, the findings for 1996 in grades four and eight indicate no association between the percentage of teachers and mean achievement.

Section Five

Section five documents the characteristics and contribution of Study Five to the synthesis of mathematics achievement (Fetler, 1999). The study investigates the relationship between the percentage of teachers with emergency permits and three grade levels of school-level student achievement scores. Table 3.11 presents the study characteristics for each grade level.

Independent Variable

For each grade, the continuous independent variable was the percentage of mathematics teachers with emergency permits. Emergency permits refer to teachers who have (a) a Bachelor's degree, (b) passed a basic skills test, and (c) completed a minimum of 18 semester hours or 9 upper division/graduate semester units of course work in

mathematics. “Emergency permits are used to hire individuals who lack some requirements for a certificate, usually proof of competence in their subject of instruction or pedagogy.” (Fetler 1999, pg 5)

Table 3.11
Characteristics of Study Five for Mathematics Achievement

Grade Level	Dependent Variable	Independent Variable (Certification Status)	Research Design
Grade 9	School-level Stanford Achievement Test scores	Percentage of teachers with emergency permits	Correlation and Regression
Grade 10	School-level Stanford Achievement Test scores	Percentage of teachers with emergency permits	Correlation and Regression
Grade 11	School-level Stanford Achievement Test scores	Percentage of teachers with emergency permits	Correlation and Regression

Dependent Variable

The continuous dependent variable utilized in the study was school-level mean test scores for the mathematics portion of the Stanford Achievement Test Series, Ninth Edition (SAT9).

Control Variable

The control variable, poverty, is defined as the percentage of students in a school's attendance area who are from families receiving aid (AFDC). The correlation coefficient associated with each grade represents the partial correlation between the independent and dependent variable with the effect of poverty removed from both

A detailed description of the purpose of the study, research design and definition of terms are contained in Appendix E.

Effect Size Estimates

Table 3.12 presents the input data for grades nine, ten and eleven. The partial correlation between the percentage of emergency permits and school-level SAT9 scores yielded one coefficient for each grade. A discussion of the correlational findings for each grade is presented below.

Table 3.12
Study Five Input Data for Mathematics Achievement

Grade	Partial Correlation between the Percentage of Teachers with Emergency Permits and School-level Stanford Achievement Test scores	Control Variable
Grade 9	-0.241*	
Grade 10	-0.215*	Student Poverty
Grade 11	-0.236*	

* p< .05

Ninth Grade

When the effect of poverty is controlled, the school-level correlation between the percentage of teachers with emergency permits and the corresponding mean SAT9 score yielded a significant coefficient of -0.241. An increase of one standard deviation in the percentage of teachers in schools with emergency permits corresponds to a decrease of 25 percent of a standard deviation in mean achievement.

Tenth Grade

Controlling for the effect of poverty, the school-level correlation between the percentage of teachers with emergency permits and the corresponding mean SAT9 score yielded a significant coefficient of -0.215. An increase of one standard deviation in the percentage of teachers in a school with emergency permits translates into approximately a decrease of 20 percent of a standard deviation in mean achievement.

Eleventh Grade

Controlling for the effect of poverty, the school-level correlation between the percentage of teachers with emergency permits and the corresponding mean SAT9 score yielded a significant coefficient of -0.236. A one unit increase in the percentage of teachers in a school with emergency permits translates into approximately a decrease of 23 percent of a standard deviation in mean achievement.

Summary of Findings

For each grade level involved in the study, these findings suggest that when the effect of poverty is removed from both variables, a significant negative relationship exists between high school achievement scores and the percentage of teachers with emergency permits.

Section Six

Five studies investigated the effect of certification on student achievement in mathematics. The eighteen effect size estimates generated from these studies are discussed below.

Mean Difference Effect Size Estimates

Seven mean difference effect size estimates were generated by comparing categories of certified and less-than-fully certified teachers. Table 3.13 presents the statistical significance of each comparison and the corresponding trend statement.

Of the seven mean difference effect size estimates, three are significant at the $p < 0.05$ level. These findings suggest that students of teachers with full certification in mathematics exhibit higher average achievement than students of less-than-fully certified teachers. The four non-significant effect size estimates suggest that students of sully certified teachers and students of less-than-fully certified teachers exhibit equivalent levels of achievement.

Table 3.13
Findings for Mean Difference Effect Size Estimates in Mathematics Achievement

Study	Comparison of Certification Categories: Certified	Comparison of Certification Categories: Less-than-Fully-Certified	Significant at $p < .05$	Trend
Study One	Standard Certification in Mathematics	Probationary Certification in Mathematics	no	Average achievement is equivalent for students of teachers with either standard certification or probationary certification
		Emergency Certification in Mathematics	no	Average achievement is equivalent for students of teachers with either standard certification or emergency certification
		No certification in Mathematics	yes	Average achievement is higher for students taught by teachers with standard certification than no certification
Study Two	General Mathematics Certified in Mathematics	Certified Outside Mathematics	yes	Average student achievement is higher for teachers who are certified in mathematics than for teachers certified out-of-field.
	Algebra Certified in Mathematics	Certified Outside Mathematics	no	Average student achievement is equivalent for teachers certified in mathematics or certified out-of-field.
Study Three	Full Certification in Mathematics 1998 – 1999	Under-certified in Mathematics	no	Average student achievement is equivalent for teachers who are fully certified or under-certified.
	Full Certification in Mathematics 1999 – 2000	Under-certified in Mathematics	yes	Average student achievement is higher for teachers who are fully certified.

Correlational Effect Size Estimates

Eleven estimates were generated from a correlation of average student achievement with proportions of fully certified and less-than-fully certified teachers. In each case, the effect of poverty has been removed from both variables. Table 3.14 presents each correlation coefficient, its statistical significance and the corresponding trend statement.

Although the findings are not entirely consistent, they suggest that in general, larger proportions of fully certified teachers are associated with higher average achievement. Similarly, higher average student achievement is associated with smaller proportions of less-than-fully certified teachers.

Overall Trends

Of the eighteen effect size estimates generated in the area of mathematics achievement, fourteen favor the positive effect of fully certified teachers on student achievement. Four effect sizes point toward equivalent levels of achievement for students of fully certified and less-than-fully certified teachers. In none of the cases is the level of achievement higher for students of less-than-fully certified teachers.

Although the empirical evidence is not entirely consistent, the overall trend for these eighteen effect sizes provides some support for the claim that fully certified teachers yield higher achievement in mathematics than less-than-fully certified teachers.

Table 3.14
Findings for Correlational Effect Size Estimates in Mathematics Achievement

Study	Correlation with Mean Student Achievement Scores			Significant at $p < .05$	Trend
Four	Percentage of Fully Certified Teachers	Grade 4	1992	yes	Higher average state-level achievement is associated with larger proportions of fully certified teachers
			1996	no	No association between the proportion of teachers and average achievement
		Grade 8	1990	yes	Higher average state-level achievement is associated with smaller proportions of less-than-fully certified teachers
			1996	no	No association between the proportion of teachers and average achievement
	Percentage of Less-than-Fully Certified Teachers	Grade 4	1992	yes	Higher average state-level achievement is associated with larger proportions of fully certified teachers
			1996	no	No association between the proportion of teachers and average achievement
		Grade 8	1990	yes	Higher state-level achievement is associated with smaller proportions of less-than-fully certified teachers
			1996	no	No association between the proportion of teachers and average achievement
Five	Percentage of Teachers with Emergency Permits	Grade 9		yes	For all grades, higher average school-level achievement is associated with smaller proportions of teachers with emergency permits
		Grade 10		yes	
		Grade 11		yes	

CHAPTER IV

FINDINGS FOR SCIENCE ACHIEVEMENT

This chapter presents the findings for the research synthesis on science achievement. This synthesis was undertaken in the second phase of this inquiry. Given that a single study focuses on science achievement, the chapter is comprised of one section that addresses the contribution of Study One to the synthesis of science achievement. The trends of this study are described at the end of this section.

Section One

Section one documents the characteristics and contribution of Study One (Goldhaber & Brewer, 2000) to the synthesis of science achievement. The study explores whether the type of certification held by a teacher influences student achievement in science. The study characteristics for Study One are presented in Table 4.1.

Independent Variable

One independent variable was used to investigate the effect of teacher certification on student achievement. The four levels of the independent variables are defined as follows:

5. Standard certification refers to teachers who hold a standard or regular certificate. Such teachers are regarded as fully certified and have completed all requirements designated by the state.

6. Probationary certification refers to teachers who have satisfied all requirements except the completion of a probationary period.
7. Emergency permits are held by teachers who must complete additional coursework before they can be issued a standard certificate.
8. The "no certification" category includes teachers who either are not certified and do not fall into any of the above categories. Teachers designated as not certified may not be certified in the area of science.

Each type of certification listed above refers to certification in the area of science.

Table 4.1
Characteristics of Study One for Science Achievement

School Level	Dependent Variable	Independent Variable (Certification Status)	Research Design
Secondary (12^{th} grade students)	Scores from National Educational Longitudinal Survey.	Standard certification Probationary certification Emergency certification No certification in subject area.	Regression model

Dependent Variable

The continuous dependent variable utilized in the study is individual student achievement scores taken from the National Educational Longitudinal Survey (NELS). The dependent variable is the gain in science achievement scores from tenth to twelfth grade.

Effect Size Estimates

Table 4.2 presents the input data associated with each of the following types of certification: (a) standard certification, (b) probationary certification, (c) emergency certification, and (d) no certification. The effect of certification on achievement is examined by comparing teachers with standard certificates to teachers with either probationary, emergency or no certification.

Table 4.3 presents the effect size indicators for contrasts between standard certification and the remaining three certification categories. A detailed description of the purpose of the study, the research design, input data and calculations for effect size indicators are contained in Appendix A.

Descriptive statistics for teachers with standard certification were compared to teachers with probationary certification, emergency certification and no certification in science. A discussion of the effect size estimates associated with each comparison is presented below.

Table 4.2
Study One Input Data for Science Achievement

Type of Certification	Gain from Tenth Grade to Twelfth Grade		
	M	SD	N
Standard Certification in Subject	1.87	3.71	2069
Probationary Certification in Subject	1.12	3.53	41
Emergency Certification in Subject	2.68	3.58	41
No certification in Subject	1.74	3.47	29

M = average science achievement score
SD = standard deviation of average science achievement score
N = number of observations

Table 4.3
Study One Effect Size Indicators for Science Achievement

Certification Status	Effect Size Indicators					
	S_d	d	v	M.E.	CI_{95} Lower	CI_{95} Upper
Standard Certification in Subject versus:						
Probationary Certification in Subject	3.71	0.202	0.025	0.309	-0.107	0.511
Emergency Certification in Subject	3.71	-0.218	0.025	0.309	-0.527	0.091
No certification in Subject	3.71	0.035	0.035	0.367	-0.331	0.402

S_d = pooled standard deviation
d = adjusted effect size
v = effect size variance
M.E. = margin of error
CI_{95} = 95% confidence interval for the adjusted effect size estimate

Standard Certification and Probationary Certification

A comparison of probationary certification and standard certification yielded an effect size estimate of d = 0.202. Inspection of the confidence interval reveals that this effect size estimate is not significant at the $p < 0.05$ level. Therefore, students taught by teachers with either type of certification exhibited equivalent levels of achievement in science.

Standard Certification and Emergency Certification

A comparison of emergency certification and standard certification yielded an effect size estimate of d = -0.218. Inspection of the confidence interval reveals that this effect size estimate is not significant at the $p < 0.05$ level. Therefore, students taught by teachers with either type of certification exhibited equivalent levels of achievement.

Standard Certification and No Certification

A comparison of teachers with no certification and standard certification yielded an effect size estimate of d = 0.035. Inspection of the confidence interval reveals that this effect size estimate is not significant at the $p < 0.05$ level. Therefore, students taught by teachers with either type of certification exhibited equivalent levels of achievement.

Overall Trends

One study investigated the effect of certification on student achievement in science. Three mean difference effect size estimates were generated by comparing categories of certified and less-than-fully certified teachers. Table 4.4 presents the statistical significance of each comparison and the corresponding trend statement.

None of the three mean difference effect size estimates were found to be significant at the $p < 0.05$ level. These findings indicate that students taught by teachers with full certification and students of less-than-fully certified teachers exhibit equivalent levels of achievement in science. The findings provide no support for the position that fully certified teachers yield higher achievement in science than less-than-fully certified teachers.

Table 4.4
Findings for Mean Difference Effect Size Estimates in Science Achievement

Study	Comparison of Certification Categories		Significant at $p < .05$	Trend
	Certified	Less-than-Fully-Certified		
Study One	Standard Certification in Science	Probationary Certification in Science	no	Average achievement is equivalent for students of teachers with either standard certification or probationary certification
		Emergency Certification in Science	no	Average achievement is equivalent for students of teachers with either standard certification or emergency certification
		No certification in Science	no	Average achievement is equivalent for students taught by teachers with standard certification or no certification

CHAPTER V

FINDINGS FOR READING ACHIEVEMENT

This chapter presents the findings for the research synthesis on reading achievement. This synthesis was undertaken in the second phase of this inquiry. The chapter is organized into three sections. The first two sections deal with the contribution of each study to the synthesis of mathematics achievement. The third section details the trends of these studies.

Section One

Section one documents the characteristics and contribution of Study Three (Laczko-Kerr & Berliner, 2002) to the synthesis of reading achievement. Based on scores in reading from two years of data, this study compares class-level achievement of students by matching pairs of certified and under-certified teachers from similar schools and districts. Table 5.1 presents the study characteristics for each year of data.

Independent Variable

The dichotomous independent variable refers to teachers who are either (a) fully certified, or (b) under-certified. The initial independent variable utilized in the study consisted of teachers who had one of the following types of certification: (a) full state certification, (b) emergency certification, (c) temporary certification, or (d) provisional certification. The latter three groups were combined to form one group of under-certified

teachers after results of a one-way analysis of variance (ANOVA) conducted by the authors revealed that mean scores were not statistically different.

Table 5.1
Characteristics of Study Three for Reading Achievement

School Level	Dependent Variable	Independent Variable (Certification Status)	Research Design
Data Set One 1998 - 1999			
Grades 3 – 8	Class means for Stanford Achievement Test	28 pairs of teachers consisting of one teacher from each of the following categories: Under-certified Full state certification	Ex-post-facto matched pair
Data Set Two 1999 - 2000			
Grades 3 – 8	Class means for Stanford Achievement Test	87 pairs of teachers consisting of one teacher from each of the following categories: Under-certified Full state certification	Ex-post-facto matched pair

Dependent Variable

The study utilized two separate years of student test scores in reading. Individual level student scores were aggregated at the class level to yield an average achievement score for each teacher involved in the study. The raw data therefore consisted of class-level means reported in normal curve equivalent scores (NCE). The continuous dependent variable herein refers to class-level mean achievement scores in grades three through eight for two separate years.

A detailed description of the purpose of the study, the research design, input data for each year and calculations for effect size indicators are contained in Appendix C.

Effect Size Estimates

The input data for this study yielded an effect size for each year of data. Table 5.2 presents input data for each year and the associated effect size indicators. A discussion of the effect sizes associated with each year of data is presented below.

***Data Set One**: 1998 - 1999*

A comparison of teachers fully certified in reading with under-certified teachers yielded an effect size estimate of $d = 0.641$. Inspection of the confidence interval reveals that this effect size estimate is significant at the $p < 0.05$ level.

The direction of the effect size generated for data set one suggests that the mean achievement score of classes taught by fully certified teachers is, on average, higher than

Table 5.2

Study Three Effect Size Indicators for Reading Achievement

	Certified Teachers		Under-Certified Teachers		Effect Size Indicators						
	M	SD	M	SD	N	S_d	d	v	M.E.	CI_{95}	
										Lower	Upper
Dataset One 1998 – 1999	36.52	9.59	30.67	8.02	28	9.00	0.641*	0.075	0.537	0.103	1.118
Dataset Two 1999 - 2000	35.62	9.31	32.48	9.43	87	9.42	0.332*	0.023	0.299	0.032	0.631

* $p < 0.05$
M = average reading achievement score
SD = standard deviation of average mathematics achievement score
N = number of observations
S_d = pooled standard deviation
d = adjusted effect size
v = effect size variance
M.E. = margin of error
CI_{95} = 95% confidence interval for the adjusted effect size estimate

classes taught by under-certified teachers. Whereas fifty percent of the classes taught by under-certified teachers exhibit an average reading score above the mean (M = 30.67), 74 percent of the classes taught by teachers with full state certification score above this value. Compared to classes taught by under-certified teachers, the effect of fully certified teachers on reading achievement is that an additional 24 percent of classes score above the mean.

Data Set Two: 1999 - 2000

A comparison of teachers fully certified in reading with under-certified teachers yielded an effect size estimate of $d = 0.332$. Inspection of the confidence interval reveals that this effect size estimate is significant at the $p < 0.05$ level.

The direction of the effect size for data set two indicates that on average, students of teachers with full state certification outperform their counterparts. Half the classes taught by under-certified teachers scored above the mean (M = 32.48) while 63 percent of classes taught by fully certified teachers scored above this value. Therefore, compared to classes taught by under-certified teachers, full certification in reading yields an additional 13 percent increase in the number of classes that score above the mean.

Summary of Findings

Of the two mean difference effect size estimates generated from Study Three, both were significant. For both years of data examined in Study Three, classes taught by teachers with full state certification reflect higher average achievement scores than

classes taught by under-certified teachers. These findings indicate that full state certification is associated with higher levels of achievement at the class level.

Section Two

Section two documents the characteristics and contribution of Study Four (Darling-Hammond, 2000a) to the synthesis of reading achievement. This study investigates whether the percentage of teachers with full state certification is associated with state-level National Assessment of Educational Progress (NAEP) student achievement scores.

Two separate years of state-level data representing 44 states were used in the study. The analysis focused on fourth grade reading data from 1992 and 1994. Table 5.3 presents the study characteristics for each year.

Independent Variable

For each of the two datasets, two continuous independent variables were used to investigate the role of teacher certification on student achievement. The two independent variables are defined as follows:

3. "Fully certified includes teachers with standard or regular certification and new teachers on probationary certificates who have completed all requirements for a license except for the completion of the probationary period (usually two or three of beginning teaching." (Darling-Hammond, 2000a, pg 25)

Table 5.3
Characteristics of Study Four for Reading Achievement

Research Design	Level	Continuous Independent Variable (Certification Status)	Dependent Variable
Correlation	Grade 4 1992	Percentage of teachers who are: Fully certified Less-than-fully certified	State-level NAEP achievement scores
	Grade 4 1994	Percentage of teachers who are: Fully certified Less-than-fully certified	State-level NAEP achievement scores

4. "Less-than-fully certified includes teacher with no certificate and those with provisional, temporary, or emergency certification." (Darling-Hammond, 2000a, pg 25)

Dependent Variable

For each of the two datasets, the continuous dependent variable is state-level NAEP mean achievement scores in reading.

Control Variable

For each state, the control variable, poverty, is defined as the percentage of students with family incomes below the poverty line. The correlation coefficients associated with each dataset represent the partial correlation between the independent and dependent variable with the effect of poverty removed from both. A detailed description of the purpose of the study, research design and definition of terms are contained in Appendix D.

Effect Size Estimates

Table 5.4 presents the input data for 1992 and 1994. The partial correlation of the two teacher certification variables and mean NAEP achievement scores yielded two coefficients for each year.

Table 5.4
Study Four Input Data for Reading Achievement

Data set	Partial Correlations between Teacher Certification Variables and Mean Student NAEP Achievement		Control Variable
	Percentage of Fully Certified Teachers	Percentage of Less-than-fully Certified Teachers	
Grade 4			
1992	0.57*	-0.55*	Student Poverty
1994	0.41*	-0.50*	

* p< .05

1992

Both correlation coefficients based on data from 1992 are significant. This suggests that a one standard deviation increase in the percentage of fully certified teachers corresponds to an increase of 0.57 of a standard deviation in mean achievement. Similarly, a one standard deviation increase in the percentage of less-than-fully certified teachers corresponds to a decrease of 0.55 of a standard deviation in mean achievement

1994

Both correlation coefficients based on data from 1994 are significant. This suggests that a one standard deviation increase in the percentage of fully certified teachers corresponds to an increase of 0.41 of a standard deviation in mean achievement. Similarly, a one standard deviation increase in the percentage of less-than-fully certified teachers corresponds to a decrease of 0.50 of a standard deviation in mean achievement

Summary of Findings

In all cases, the state-level findings of Study Four imply that average state-level student achievement in reading increases with greater proportions of fully certified teachers and smaller proportions of less-than-fully certified teachers.

Section Three

Two studies explored the relationship between certification and student achievement at the elementary school level. The six effect size estimates generated from these studies are discussed below.

Mean Difference Effect Size Estimates

In the area of reading achievement, two mean difference effect size estimates were generated from Study Three. Table 5.5 presents the statistical significance of each estimate and the corresponding trend. The findings are consistent across both studies and

indicate that on average, student achievement is higher for teachers with full state certification than for teachers who are under-certified.

Table 5.5
Findings for Mean Difference Effect Size Estimates in Reading Achievement

Study	Comparison of Certification Categories		Significant at $p < .05$	Trend
	Certified	Less-than-Fully-Certified		
Study Three	Full Certification in Reading 1998 – 1999	Under-certified in Mathematics	yes	For both years, average achievement is higher for students of teachers who are fully certified in reading than for those who are under-certified
	Full Certification in Reading 1999 – 2000	Under-certified in Mathematics	yes	

Correlational Effect Size Estimates

Four correlational effect size estimates were generated from Study Four. Table 5.6 presents the statistical significance of each estimate and the corresponding trend. These findings suggest that higher levels of achievement are associated with greater proportions of fully certified teachers and smaller proportions of less-than-fully certified teachers.

Overall Trends

Of the six effect size estimates generated in the area of reading achievement, all are significant and favor the positive effect of fully certified teachers on student achievement. There is no case in which the level of achievement is equivalent or higher for students of less-than-fully certified teachers.

These findings provide support for the claim that students of teachers with full certification exhibit higher achievement in reading than students of less-than-fully certified teachers.

Table 5.6
Findings for Correlational Effect Size Estimates in Reading Achievement

Study	Correlation with Mean Student Achievement Scores			Significant at $p < .05$	Trend
Study Four	Percentage Fully Certified Teachers	Grade 4	1992	yes	Higher average state-level achievement is associated with greater proportions of fully certified teachers
			1994	yes	
	Percentage of Less-than-fully Certified Teachers	Grade 4	1992	yes	Higher average state-level achievement is associated with smaller proportions of less-than-fully certified teachers
			1996	yes	

CHAPTER VI

META-ANALYSIS FINDINGS

This chapter presents the patterns and trends uncovered across common study characteristics. The chapter is organized into five sections. The first section presents characteristics of the collective effect size population examined in this inquiry. Sections two through four present the findings associated with the effect size population in terms of the following characteristics: (a) area of achievement, (b) school level, and (c) research design and unit of analysis. The final section provides a summary of these findings.

Section One

Section one examines the characteristics of the effect size population generated from this inquiry. Collectively, the effect size population consists of twenty-seven estimates. Discussions of mean difference and correlational effect size estimates are presented separately below.

Mean Difference Effect Size Estimates

Twelve mean difference effect size estimates contribute to the total effect size population. Table 6.1 presents each mean difference effect size estimate in terms of the following characteristics: (a) the study on which it is based, (b) area of achievement, (c) unit of analysis, (d) school level, and (e) properties of the independent variable.

Table 6.1
Characteristics of the Mean Difference Effect Size Population

Effect #	Study	Area of Achievement	Mean Difference Test Statistic	School Level	Independent (Predictor) Variable
d_1	One	Mathematics	Individual-level Scores	High School	Teachers with standard certification versus teachers with either probationary, emergency, or no certification
d_2					
d_3					
d_4	Two		Individual-level Scores	High School	At both school levels, teachers certified in mathematics versus teachers certified out-of-field
d_5				Middle	
d_6	Three		Class-level Mean	Elementary	Teachers fully certified in mathematics versus under-certified
d_7				Elementary	
d_8	One	Science	Individual-level Scores	High School	Teachers with standard certification versus teachers with either probationary, emergency, or no certification
d_9					
d_{10}					
d_{11}	Three	Reading	Class-level Mean	Elementary	Teachers fully certified in reading versus under-certified
d_{12}				Elementary	

A review of Table 6.1 reveals the extent to which characteristics are shared among the twelve effect size estimates. It is important to note that all estimates are based on either an individual or class level unit of analysis. For example, the six mean difference estimates associated with Study One differ only in terms of the area of achievement; three are associated with mathematics and three with science. It is also evident that definitions for the independent variable, certification status, are unique to each study.

Correlational Effect Size Estimates

Fifteen correlational effect size estimates make up the balance of the total effect size population. Table 6.2 presents each of the fifteen estimates in terms of the following characteristics: (a) the study on which it is based, (b) area of achievement, (c) unit of analysis, (d) school level, and (e) properties of the independent variable. It is important to note that each of the fifteen estimates refers to a first order correlation between an independent and dependent variable with the effect of student poverty removed from both.

A review of Table 6.2 reveals the extent to which characteristics are shared among correlational effect size estimates. For example, it is evident that all estimates originate from studies four and five and reflect only the areas of mathematics and reading. Furthermore, all estimates are based on either a school or state-level unit of analysis.

Table 6.2
Characteristics of First Order Correlational[a] Effect Size Estimates

Effect	Study	Area of Achievement	School Level	Dependent Variable	Independent (Predictor) Variable
r_1	Four	Mathematics	Elementary	State-level Mean Scores	Proportion of fully certified teachers
r_2					
r_3			Middle		
r_4					
r_5			Elementary	State-level Mean Scores	Proportion of less-than-fully certified teachers
r_6					
r_7			Middle		
r_8					
r_9	Five		High School	School-level Mean Scores	Proportion of teachers with emergency permits
r_{10}					
r_{11}					
r_{12}	Four	Reading	Elementary	State-level Mean Scores	Proportion of fully certified teachers
r_{13}					
r_{14}			Elementary	State-level Mean Scores	Proportion of less-than-fully certified teachers
r_{15}					

a The control variable for all first order correlations is the percent of student poverty

Overall Effect Size Population

A review of the effect size population reveals that the extent to which individual effect size estimates share specific study characteristics, is severely limited. This limitation is due to the fact that few of the twenty-seven effects share a common target population, equivalent operational definitions for the independent variable or a common test statistic.

The most critical issue involved with the interpretation of the effect size population is that operational definitions for the independent variable vary widely across the five studies. In studies One, Two and Three, each certification group is defined by one specific credential. For example, in Study One, teachers with either emergency, probationary or no certification are compared to teachers with standard certification. In Study Two, the two groups of teachers are either (a) certified in mathematics or reading, or (b) certified in another field. The disparate definitions of certification do not permit effect size estimates to be combined.

The lack of common characteristics precludes the use of confirmatory meta-analysis (Hedges & Olkin, 1985). However, these effect size estimates are sufficient for an exploratory meta-analysis (McNamara, 1998) which focuses on a review of study outcomes such as the significance and direction of effect size estimates rather then their numerical values. In exploratory meta-analysis, studies with diverse characteristics are assembled to reveal relationships among variables of interest and to suggest directions for additional research (Light & Pillemer, 1984).

In order for studies to be synthesized in a meaningful way, common characteristics must be identified. It is evident from the discussion in the previous section that each effect size refers to levels of student achievement associated with distinctly defined groups of teachers. In order to synthesize the diverse set of certification groups, these distinct groups have been collapsed into two broad groups; fully certified teachers and less-than-fully certified teachers. Therefore, the balance of the chapter examines study outcomes for fully certified teachers and less-than-fully certified teachers.

Given that each mean difference effect size estimate reflects a comparison of the average student achievement level for fully certified and less-than-fully certified groups of teachers, three outcomes are possible: higher achievement for (a) fully certified teachers, (b) neither fully certified nor less-than-fully certified (equivalent levels of achievement), or (c) less-than-fully certified teachers. It is important to note that there were no statistically significant effect size estimates in which higher achievement was associated with less-than-fully certified teachers. Therefore, mean difference effect size estimates are tabulated in terms of two outcomes: higher achievement is associated with (a) fully certified teachers, or (b) neither fully certified nor less-than-fully certified (equivalent levels of achievement).

Three additional outcomes are possible for correlational effect size estimates: higher achievement is associated with (d) larger proportions of fully certified teachers, (e) no association between the proportion of teachers and student achievement, and (f) smaller proportions of less-than-fully certified teachers. Given that the latter category is the complement of larger proportions of fully certified teachers, these outcomes are

presented together. Therefore, in the balance of this chapter, effect sizes estimates are presented in terms of four outcomes: higher achievement is associated with (a) fully certified teachers, (b) neither fully certified nor less-than-fully certified (equivalent levels of achievement), (d) larger proportions of fully certified teachers or smaller proportions of less-than-fully certified teachers, and (e) no association between the proportion of teachers and student achievement.

Section Two

Section two examines the findings for the effect size population across the achievement areas of mathematics, science and reading.

Trends Across Areas of Achievement

Based on the total population of twenty-seven effect size estimates, Table 6.3 presents the achievement outcomes for the areas of mathematics, science and reading. Outcomes are tabulated for each category described in the previous section. Inspection of the table reveals mixed results in mathematics where eleven out of eighteen total outcomes favor the positive effect of fully certified teachers. In the areas of science and reading, each set of outcomes is consistent. All three science outcomes signify equivalent levels of achievement for both categories of teachers. Conversely, in reading, all six outcomes point toward the positive effect of certified teachers.

Table 6.3
Number of Outcomes Distributed Across Areas of Achievement

Outcome	Area of Achievement			
	Mathematics	Science	Reading	Total
Higher average student achievement is associated with:				
Fully Certified Teachers[a]	4	0	2	6
Greater proportions[b] of fully certified teachers or smaller proportions[b] of less-than-fully certified teachers	7	NA	4	11
Subtotal for Significant Outcome	11	0	6	17
Neither[a] (levels of achievement are equivalent for fully certified and less-than-fully certified teachers)	3	3	0	6
No association between the proportion of teachers and student achievement[b]	4	0	0	4
Subtotal for Non-significant Outcomes	7	3	0	10
Grand Total	18	3	6	27

Note. Values denoted as NA signify that this achievement area was not part of the analysis
[a] Categories denote mean difference effect size estimates
[b] Categories denote correlational effect size estimates

Section Three

Section three examines the findings for the effect size population across three school levels that include elementary, middle, and high school.

Trends Across School Levels

Table 6.4 presents the outcomes for the total population of twenty-seven effect size estimates distributed across elementary, middle and high school levels. Inspection of the table reveals mixed results at the elementary level where all but three of the twelve total outcomes favor the positive effect of fully certified teachers. At the high school level, the ten outcomes are equally divided, with: half favoring the positive effect of fully certified teachers and the other half signifying equivalent levels of achievement for fully certified and less-than-fully certified teachers. At the middle school level, results are mixed with three out of five outcomes pointing toward higher levels of achievement for fully certified teachers.

Table 6.4
Number of Outcomes Distributed Across School Levels

Outcome	School Level			
	Elementary	Middle	High School	Total
Higher levels of student achievement are associated with:				
Fully Certified Teachers[a]	3	1	2	6
Larger proportions[b] of fully certified teachers or smaller proportions[b] of less-than-fully certified teachers	6	2	3	11
Subtotal for Significant Outcomes	9	3	5	17
Neither[a] (levels of achievement are equivalent for fully certified and less-than-fully certified teachers)	1	0	5	6
No association between the proportion of teachers and student achievement[b]	2	2	0	4
Subtotal for Non-significant Outcomes	3	2	5	10
GrandTotal	12	5	10	27

[a] Categories denote mean difference effect size estimates
[b] Categories denote correlational effect size estimates

Section Four

Section four examines the findings for the effect size population across four levels of analysis that include individual, class, school and state.

Trends Across Research Design and Level of Analysis

Table 6.5 presents the outcomes for the total population of twenty-seven effect size estimates distributed across individual, class, school, and state levels of analysis. There appears to be some relationship between level of analysis and outcome. A majority of outcomes at the individual level of analysis are non-significant, while outcomes at the class, school and state levels of analysis are dominantly or consistently significant.

However, interpretation of these trends is complicated by the fact that level of analysis is correlated with the type of effect size estimate. Inspection of the table reveals that outcomes based on an individual or class level of analysis correspond to the twelve mean difference effect size estimates. Similarly, outcomes based on a school or state level of analysis corresponds exactly to the fifteen correlational effect size estimates. Since the level of analysis is a part of the research design, outcomes are reviewed according to the type of research design.

The twelve mean difference outcomes based on either an individual or class level of analysis are evenly divided with half pointing towards the positive effect of fully certified teachers and the other half signifying equivalent levels of achievement for the two groups. Of the fifteen correlational outcomes based on a state or school level of

Table 6.5
Number of Outcomes Distributed Across Levels of Analysis

Outcome	Level of Analysis				Total
	Individual	Class	School	State	
Higher levels of student achievement are associated with:					
Fully Certified Teachers[a]	3	3	NA	NA	6
Larger proportions[b] of fully certified teachers or smaller proportions[b] of less-than-fully certified teachers	NA	NA	3	8	11
Subtotal for Significant Outcomes	3	3	3	8	17
Neither[a] (levels of achievement are equivalent for fully certified and less-than-fully certified teachers)	5	1	NA	NA	6
No association between the proportion of teachers and student achievement[b]	NA	NA	0	4	4
Subtotal for Non-significant Outcomes	5	1	0	4	10
Grand Total	8	4	3	12	27

Note. Values denoted as NA signify that the level of analysis is utilized in the corresponding outcome category.
[a] Categories denote mean difference effect size estimates
[b] Categories denote correlational effect size estimates

analysis, eleven point toward the positive effect of larger proportions of fully certified teachers and smaller proportions of less-than-fully certified teachers.

Section Five

This section summarizes the trends uncovered across areas of achievement, school levels, and unit of analysis.

Area of Achievement

In mathematics and reading, there is some evidence to suggest that fully certified teachers yield higher achievement than less-than-fully certified teachers. However, in science, the evidence points toward equivalent levels of achievement for the two groups of teachers. These findings suggest that the effect of certification on student achievement is not uniform across the three areas of achievement and therefore, may be more crucial to student achievement in mathematics and reading.

School Level

At the elementary, the overall findings suggest that fully certified teachers yield higher achievement than less-than-fully certified teachers. At the middle and high school levels, the equally divided results prevent identification of an overall trend. Given that the effect of certification appears to vary by school level, full certification may be more crucial to student achievement at the elementary level than at the middle or high school level.

Research Design and Level of Analysis

Research designs that utilize school or state-level means also use continuous quantitative variables such as the proportion of teachers holding specific credentials. These designs yield mixed results but the outcomes generally favor the effect of fully certified teachers.

Results of designs that compare the achievement of students at the individual or class level are equally divided between those that favor the effect of fully certified teachers and those that yield equivalent results. Therefore, it is possible that aggregate levels of analysis and correlational research design contribute to a greater number of outcomes that favor the positive effect of fully certified teachers.

Overall Conclusions

Although definitive conclusions about the overall effect of certification on student achievement are problematic, the findings uncovered across achievement areas, school levels and unit of analyses illuminate issues that are vital to an understanding of the topic.

Of the twenty-seven outcomes associated with each effect size estimate, the empirical evidence on the effect of teacher certification suggests that in some cases and given certain conditions, fully certified teachers yield higher levels of student achievement than less-than-fully certified teachers. Therefore, the findings generated from the analyses of the effect size population do not provide categorical support for either

position outlined by The Abell Foundation or the National Commission on Teaching and America's Future.

CHAPTER VII

RECOMMENDATIONS

This chapter provides a discussion of study limitations and offers recommendations for future research and educational policy on teacher certification. The chapter is organized into three sections. The first section provides a critical review of issues involved in the interpretation of findings. The second section offers recommendations for researchers planning to study the effect of teacher certification on student achievement. The final section provides recommendations for policymakers at the state and federal level who are involved in setting standards and planning legislation for educator preparation.

Section One

This section discusses the limitations of the findings associated with the effect size estimates. Each of the twenty-seven effect size estimates provides some evidence of the effect of teacher certification on student achievement. The meta-analysis findings pointed to several study characteristics and conditions that restrict the interpretation of findings. A discussion of the limitations associated with correlational and mean difference effect sizes is presented separately below. The section concludes with a discussion of general limitations.

Correlational Effect Size Estimates

The fifteen correlational effect size estimates generated from Studies Four and Five were based on correlation of mean student achievement with the proportion of fully and less-than-fully certified teachers. Several key issues are worthy of consideration in interpreting these findings and are presented below.

Independent Variable

A fundamental problem associated with the correlational effect size estimates examined in this study is the nature of the independent variable. The use of a continuous quantitative independent variable reflecting the proportion of fully certified and less-than-fully certified teachers does not allow for a comparison of student achievement between the two groups. Controlling for the effect of student poverty, these correlations provide an index of the association between the proportions of teachers and mean achievement. Therefore, the findings of Studies Four and Five augment the position that fully certified teachers yield higher levels of student achievement but they do not offer direct evidence.

Unit of Analysis

A second issue associated with the correlational effect size estimates is the use of school or state level means in place of individual level student data. The use of individual-level scores tied to certified or uncertified teachers permits detailed analysis of relevant student and teacher characteristics. As student and teacher information is

aggregated to increasingly broad levels, the relationship between student achievement and teacher certification becomes more general.

In Study Four, student achievement was represented by a single state-level mean and paired with the proportion of certified teachers in the state. The aggregation of student achievement scores to state means results in a reduction of variance that obscures information about potential differences among individual students, teachers, classrooms, schools and school districts. Similarly, the use of data aggregated to the school level in Study Five overlooked differences among students, teachers, and classrooms. Therefore, the value of the findings from these studied is lessened by the use of aggregate data.

Mean Difference Effect Size Estimates

The twelve mean difference effect size estimates generated from studies One, Two and Three were based on achievement level comparisons for certified and less-than-fully certified teachers. Issues important to the interpretation of findings are presented below.

Unbalanced Designs

In Study One, comparisons of standard certification to other types of certification were based on highly disproportionate sample sizes. For example, in mathematics, the standard certification category was based on 3179 cases but probationary, emergency, and no certification groups were based on 24, 49 and 77 cases, respectively. Ideally, to maximize statistical power, groups should be comparable in size.

In Study One, this limitation is overcome by the excessively large size of the standard certification category. The statistical power and corresponding small standard or error stems from one excessively large category. Had the sample size been smaller and disproportionate, statistical power would be reduced. A significant finding would have necessitated a much larger difference between means to achieve statistical significance.

Conversely, the three non-significant findings in science and the two in mathematics are particularly noteworthy in light of the statistical power of Study One. As sample size increases, statistical power increases and the error probability, or failure to detect a difference, is minimized. It is unlikely that a true difference in achievement for any comparison went undetected.

Levels of the Independent Variable

In Study Three, effect size estimates represent to the combined average achievement of elementary and middle school levels. Although the authors conducted separate analyses for the elementary level, only total statistics were reported. For the purposes of this meta-analysis, these results were designated as elementary even though middle school achievement is included. These effect size estimates hindered the ability to interpret findings and make conclusions about the effect of certification across school levels. This is especially noteworthy given that the trend for middle school was found to be similar to the trend for high school.

Overall Research Evidence

In general, the research designs used in Studies One, Two and Three are better suited to addressing the effect of teacher certification on student achievement than the design used in Studies Four and Five. The use of a continuous quantitative certification variable along with state-level means call into question the contribution of Studies Four and Five to the overall evidence. In contrast, the mean difference effect size estimates generated from Studies One through Three utilized individual and class level data and a dichotomous or categorical certification variable. Combined with an appropriate research design these studies provided the strongest evidence for the effect of certification.

For example, Study Three utilized a matched pair research design where individual students are paired according to similar levels of ability and teachers are paired according to similar levels experience and background. The effect of the particular school or school district on student achievement is detected by pairing teachers within the same school and school district. This design provides direct evidence of differences in achievement for groups of fully and under-certified teachers.

The within-subject design used in Study One is also a useful method for studying the effect of certification. The average gain in achievement from one year to the next is compared for students of fully certified and less-than-fully certified teachers. Student ability is reflected in scores from both years so any difference from one year to the next reflects a gain in achievement. Differences in performance can be attributed to the quality of instruction and not to pre-existing advantages in student ability.

It is important to note that the pre-test post-test design used in Study Two does not control for differences in ability between groups of students but pre-test means were tested for equivalence. However, all three designs are well-suited for detecting differences in achievement for groups fully and less-than-fully certified teachers.

In general, evidence on the effect of teacher certification should be evaluated in terms of several research design characteristics. It is clear that the mean difference effect size estimates provide the strongest evidence for the effect of teacher certification.

General Limitations

The above discussion highlights issues that are unique to interpreting correlational and mean difference effect size estimates. Several issues common to the total effect size population are important to consider in interpreting the evidence on teacher certification.

Quantity of Studies

The foremost issue associated with the interpretation of evidence is that it is based on a small number of studies. Given the scope of this inquiry, few studies examine the effect of certification status on student achievement. Even fewer studies specifically focus on a direct comparison of teacher credentials and their effect on student achievement. By and large, the body of direct and reliable evidence accumulated on this topic is meager.

Identification of Trends

The small number of studies examined in this inquiry poses problems in forming conclusions about the effects of certification. It is clear that trends associated with specific achievement areas, school levels and units of analysis are closely tied to the unique characteristics of each of the five individual studies. When studies are grouped according to specific characteristics, recurring study characteristics seemingly emerge as trends.

The effect size estimates generated in the area of science illustrate this issue. The three estimates associated with science achievement are based on a single study. It follows that any conclusions about the effect of certification in science, in fact, refer to the findings for the particular study. Similarly, the mean difference effect size estimates associated with the elementary school level are based on a single study. Conclusions about the effect of certification at this level rely solely on the design characteristics of one study and not on effect size estimates from a variety of sources.

Given that each effect size reflects specific study characteristics, the capacity to distinguish between genuine trends and idiosyncratic study features is severely limited. Therefore, definitive conclusions about the effect of teacher certification on a particular achievement area or school level are problematic.

Lack of Reporting

The omission of important descriptive statistics on student and teacher variables is common to all studies. Study Four and Five utilized regression procedures to investigate

the teacher credentials and student achievement. Although the mean mathematics achievement score was reported for each grade level, standard deviations were not. This omission precludes the use of regression coefficients in the calculation of effect sizes. Estimates of the effect of teacher certification for these studies were relegated to correlation coefficients.

As mentioned earlier, in Study Three, class-level mean scores for grades three through eight and grades three through six were analyzed separately. In lieu of reporting separate results for grades three through six, the authors provided general information on the statistical significance of these analyses. This omission did not allow for separate estimates of achievement to be generated for the elementary level. Rather, the effect size estimates generated for this study represent to the achievement of elementary and middle school levels combined. These estimates interfered with the interpretation of findings for the elementary and middle school levels.

Section Two

Based on the limitations described in section one, section two offers recommendations for researchers planning to study the effect of teacher certification on student achievement.

Research Design

It is clear from the previous discussion that certain research designs are effective methods for examining the effect of teacher certification on student achievement. The following recommendations pertain to important features of the research design.

Independent Variable

Recommendation One: In designing a study, efforts should be made to group teachers according to well-defined credentials. Levels or types of certification should be represented by a dichotomous independent variable so that comparisons can be made between and among groups.

Analysis of the Independent Variable

Recommendation Two: Levels of the independent variable such as school level and area of achievement should be analyzed separately. This practice allows conclusions to be reached for each level and across levels.

Unit of Analysis

Recommendation Three: Individual-level student data should be the basic unit of analysis in a study. Estimates of individual variation within classes, schools or school districts provide information on potential differences across these levels.

Balanced Design

Recommendation Four: To maximize the statistical power to detect a difference in certification categories and minimize the probability that that an actual difference goes undetected, a balanced design should be used.

General Recommendations

Plans for future research also call for recommendations that enhance the body of evidence on teacher certification and student achievement. Four such recommendations are presented below.

Reporting of Information

Recommendation Five: Basic descriptive statistics including means, standard deviations and pair-wise correlations should be reported for all variables. Descriptive statistics reported for each level of variable allow for comparisons within and across levels. This practice allows study findings to be used ina future meta-analyses.

Quantity of Studies

Recommendation Six: Additional studies should be conducted that examine teacher certification and its impact on student achievement. Additional studies would increase the ability to generalize beyond unique study characteristics

and provide more conclusive evidence of certification's effect across school levels and achievement areas.

Value-added Assessment

With the exception of Study One, the studies involved in this inquiry focused on the effect of certification on student achievement within a single year. However, the effect of certification on student achievement occurs over the course of a student's entire education. Value-added measures examine the cumulative effect of a series of fully certified and less-than-fully certified teachers over several years (Sanders & Horn, 1998). Value-added assessment focuses on learning gains from one year to the next instead of exact test scores.

Recommendation Seven: A series of longitudinal studies that examine the cumulative effect of a series of fully certified and less-than-fully certified teachers on student achievement should be undertaken.

New Federal Certification Policies

The policy changes required of the No Child Left Behind act (U.S. Department of Education, 2002) have implications for researchers interested in teacher certification. Directed at improving teacher quality, the initiative requires all public elementary and secondary school teachers of core academic subjects to be highly qualified by the end of the 2005 – 2006 school year. The term "highly qualified" refers to teachers who have: (a) obtained full state certification and hold a license to teach in that state, and (b) not

had certification or licensure requirements waived on an emergency, temporary or provisional basis.

Recommendation Eight: Plans should be made to study the effects of the No Child Left Behind act. The mandate that all teachers be certified is certain to change the definition of certification and well as the composition of the teacher work force. Student achievement should be studied in order to evaluate the impact of this measure.

Summary

The recommendations above are intended to improve the quality and quantity of research on teacher certification by highlighting appropriate methods and practices. Together, these recommendations illustrate methods and practices that will enhance future meta-analyses on the topic.

Section Three

This section presents recommendations for policymakers at the state and federal level who are involved in setting standards and planning legislation for educator preparation. The recommendations presented below are based on issues that surfaced during the synthesis of studies.

Availability of Data

A fundamental concern for future research in the area of teacher certification is the availability of data in which students are linked to teachers. Studies that have capitalized on such data have either been on a small scale (Hawk, Coble & Swanson, 1985) or utilized the NELS database (Goldhaber & Brewer, 2000). The dearth of individual-level student data has forced researchers to rely on data made available by the state (Darling-Hammond, 2000; Fetler, 1999). In lieu of individual scores and teacher certification status, state databases typically report class-level mean achievement and the percentage of teachers holding various types of credentials.

> **Recommendation One:** In order to effectively examine the contribution of teacher certification to student achievement, researchers must have access to student and teacher data. A need exists for school districts and state departments of education to recognize the importance of student and teacher level data and be willing to grant limited access to select researchers. The availability of data with students linked to teachers is essential to increasing the amount of research and improving its quality.

Use of Research in Policy Decisions

Research evidence is routinely cited in discussions of policy decisions. Several issues are important to the use of research evidence in policy decisions. The No Child Left Behind act (U.S. Department of Education, 2002) calls for all public elementary and secondary school teachers of core academic subjects to be “highly qualified” by the end

of the 2005 – 2006 school year. The basis for these reforms is research evidence on teacher certification. In a report by the U.S. Department of Education (2002), the following statement refers to research evidence on the topic:

> In a recent study, economists Dan Goldhaber and Dominic Brewer (2000) found that while certified math and science teachers outperformed those who lack certification (as measured by their students' achievement), there was no statistical difference in performance between teachers who attended conventional training programs and received traditional teaching licenses versus those who did not complete such programs and were teaching on emergency or temporary certificates. (p. 8)

Interpretation of Findings

Although the findings of Study One (Goldhaber & Brewer, 2000) indicated that achievement was higher for students of certified math teachers, the difference was not statistically significant in science. Equivalent levels of achievement were exhibited by students of certified teachers and teachers with no certification.

> **Recommendation Two:** Study findings should be interpreted and presented in terms of their statistical significance. Attention to the general direction of non-significant findings provides erroneous conclusions that do not accurately represent the effect of certification.

Quantity of Studies

Recommendation Three: Prior to effecting new certification policies it is important to thoroughly review the entire body of evidence. A review that reveals a meager body of evidence should warrant additional research on the topic so that informed policy decisions can be made.

Policy Decisions on Certification

The meta-analysis findings raise the possibility that the effect of certification is not uniform across achievement areas or school levels. Certification may be more essential to student achievement at the elementary level and in the area of reading.

Recommendation Four: Broad certification policies that apply to all school levels and achievement areas should be reconsidered in favor of research-based policies that target areas where certification has the greatest positive impact.

Summary

The above recommendations are directed towards policy-makers involved with decisions on teacher certification. These recommendations are intended to maximize the value of research-based decisions.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

This chapter provides a summary of the findings generated from the inquiry. Comprised of three sections, the first section provides a description of the purpose and design of the study. The second section provides a summary of findings for the three areas of achievement and for the trends uncovered across study characteristics. The final section concludes with an overview of the recommendations proposed for continuing research and policy decisions.

Purpose and Design

The overall purpose of this study was to review the empirical research evidence accumulated to date on the effect teacher certification on student achievement. A research synthesis was conducted on studies that examined the effect of fully certified and less-than-fully certified teachers on student achievement.

The intent of this inquiry was accomplished using a research design consisting of four sequential phases and twelve research questions. Table 8.1 presents the model for the inquiry. Subsumed within each sequential phase were a unique set of research questions that guided the review of empirical research on teacher certification and student achievement. The four phases were designed to guide the inquiry toward (a) a synthesis of findings, and (b) recommendations for future research and policy decisions. A summary of these findings and recommendations follows below.

Findings

A summary of the findings for the research synthesis conducted on the effect of teacher certification on student achievement is presented in three sections that include (a) the meta-analysis population, (b) areas of achievement, and (c) meta-analysis findings.

The Meta-analysis Population

Four different search strategies were used to obtain studies for the analysis and yielded a total of five studies. Three studies utilized either an individual level or class level of analysis and yielded twelve mean difference effect size estimates. Two studies utilized either a school or state level of analysis and yielded fifteen correlational effect size estimates. Therefore, the meta-analysis population was based on five studies that generated a total of twenty-seven effect size estimates.

Area of Achievement

Mathematics

The majority of findings favored the positive effect of certified teachers. The overall trend provides some support for the position that fully certified teachers yield higher achievement than less-than-fully certified teachers.

Science

The overall trend provides no support for the position that fully certified teachers yield higher achievement in mathematics than less-than-fully certified teachers.

Reading

All the findings associated with reading favored the positive effect of fully certified teachers on student achievement. The overall trend supports the position that higher student achievement is associated with fully certified teachers.

Meta-Analysis Findings

Achievement Area

The overall trends suggest that certification may be more crucial to student achievement in reading in mathematics than in science.

School Level

Across school levels, the overall trends suggest that full certification may be more crucial to student achievement in elementary school than middle or high school.

Research Design and Level of Analysis

Research designs that utilized school or state-level means yielded results that pointed toward the positive effect of fully certified teachers. Research designs that compared student achievement at the individual or class level did not reveal a trend. It is possible

that research designs utilizing aggregate levels of analysis contributes to a larger number of positive study outcomes.

Recommendations

Recommendations based on the research synthesis on the effect of teacher certification on student achievement are summarized in two parts. Part one summarizes recommendations for academic researchers who intend to examine the effect of teacher certification status on student achievement. Part two summarizes the recommendations for policy-makers involved in investigating or reforming standards and practices related to teacher certification

Academic Research

A review of the individual studies in the meta-analysis highlighted areas in which future studies can be improved and allow for future meta-analyses to be conducted. Eight specific recommendations were directed towards academic researchers who intend to examine the effect of teacher certification status on student achievement.

> **Recommendation One:** In designing a study, efforts should be made to group teachers according to well-defined credentials. Levels or types of certification should be represented by a dichotomous or categorical independent variable so that comparisons can be made between and among groups.

Recommendation Two: Levels of the independent variable such as school level and area of achievement should be analyzed separately. This practice allows conclusions to be reached for each level and across levels.

Recommendation Three: Individual-level student data should be the basic unit of analysis in a study. Knowledge of individual variation within classes, schools or school districts yields information on potential differences across these levels.

Recommendation Four: To maximize the statistical power to detect a difference in certification categories and minimize the probability that that an actual difference goes undetected, a balanced design should be used.

Recommendation Five: Basic descriptive statistics including means, standard deviations and pair-wise correlations should be reported for all variables. Descriptive statistics reported for each level of variable allow for comparisons across levels. This practice allows study findings to be included in future meta-analyses.

Recommendation Six: Additional studies should be conducted that examine teacher certification and its impact on student achievement. Additional studies would increase the ability to generalize beyond unique study characteristics

and provide more conclusive evidence of certification's effect across school levels and achievement areas.

Recommendation Seven: Longitudinal studies that examine the cumulative effect of a series of fully certified and less-than-fully certified teachers on student achievement should be undertaken.

Recommendation Eight: Plans should be made to study the effects of the No Child Left Behind act. The mandate that all teachers be certified is certain to change the definition of certification and well as the composition of the teacher work force. Student achievement should be studied in order to evaluate the impact of this measure.

Summary

The above recommendations are directed towards researchers planning to study the effect of teacher certification. These recommendations are intended to ensure that individual studies can be included in future meta-analyses.

Educational Policy

Four recommendations were directed towards policy-makers at the state and federal level who are involved in setting standards and planning legislation for educator preparation.

Recommendation One: In order to effectively examine the contribution of teacher certification to student achievement, researchers must have access to student and teacher data. A need exists for school districts and state departments of education to recognize the importance of student and teacher level data and be willing to grant limited access to select researchers. The availability of data with students linked to teachers is essential to increasing the amount of research and improving its quality.

Recommendation Two: Study findings should be interpreted and presented in terms of their statistical significance. Attention to the general direction of non-significant findings provides erroneous conclusions that do not accurately represent the effect of certification.

Recommendation Three: Prior to effecting new certification policies it is important to thoroughly review the entire body of evidence. A review that reveals a meager body of evidence should warrant additional research on the topic so that informed policy decisions can be made.

Recommendation Four: Broad certification policies that apply to all school levels and achievement areas should be reconsidered in favor of

research-based policies that target areas where certification has the greatest positive impact.

Summary

The above recommendations are directed towards policy-makers involved with decisions on teacher certification. These recommendations are intended to maximize the value of research-based decisions.

Conclusion

The rationale for this meta-analysis was based on the debate over teacher certification elaborated in "Teacher Quality and Student Achievement: A Review of State Policy Evidence," (Darling- Hammond, 2000a) and "Teacher Certification Reconsidered: Stumbling for Quality," (Walsh, 2001) provided. This analysis made several contributions to the body of research on the effect of teacher certification status on student achievement. First, individual studies that specifically examined the effect of certification on student achievement were identified. Second, for each study, effect size estimates were calculated to provide a quantitative representation of certification's effect. Third, outcomes associated with effect sizes were synthesized to provide a comprehensive account of the amount of evidence that supports or disputes the positive effect of certification. Lastly, the synthesis of outcomes was reviewed to identify the circumstances and conditions in which the positive effect of certification occurs most

often. Therefore, this study provides an objective statement on what is known about the effect of certification status on student achievement.

The most remarkable finding of the meta-analysis is that the amount of research evidence on the topic is limited to five studies. The lack of an extensive research base is surprising in light of the on-going debate over the value of certification. In addition, the synthesis of outcomes illuminated several conditions and circumstances in which full certification has the greatest impact. Fully certified teachers appear to have the greatest effect at the elementary level and in the area of reading. This finding is noteworthy because it suggests that the effect of teacher certification is more pronounced in certain contexts. In lieu of a broad, overall appraisal, certification should be evaluated in terms of specific school and subject-level effects.

Statements regarding the contextual effects must be interpreted with caution however, because certain research designs may be associated with a greater number of positive outcomes. The majority of outcomes pointed towards the positive effect of fully certified teachers on student achievement. However, among the study designs that most directly address the topic at the individual-level, the majority of outcomes point to equivalent levels of achievement for fully and less-than-fully certified teachers. This highlights the difficulty in interpreting existing data, and points to the need for additional research.

REFERENCES

Biniaminov, I. & Glasman, N. (1983). School determinants of student achievement in secondary education. *American Educational Research Journal. 20*(2), 251-268.

Brewer, D. J. & Goldhaber, D. D. (1998, November). Improving longitudinal data on student achievement: Some lessons from recent research using NELS:88. In Grissmer, D. W. & Ross, J. M. (Eds.), *Analytic issues in the assessment of student achievement.* Proceedings of the National Center for Education Statistics research seminar, Washington, DC

Cook, T. D., Cooper, H., Cordray, D.S., Hartmann, H., Edges, L. V., Light, R. J., Louis, T. A., & Mosteller, F. (1994). *Meta-analysis for explanation: A casebook*. New York, NY: Russell Sage Foundation.

Darling-Hammond, L. (1996). *What matters most: Teaching for America's future*. National Commission on Teaching and America's Future. New York: Teachers College, Columbia University.

Darling-Hammond, L. (1997). *Doing what matters most: Investing in quality teaching.* National Commission on Teaching and America's Future. New York: Teachers College, Columbia University.

Darling-Hammond, L. (1999). *Solving the dilemmas of teachers supply, demand, and standards: How we can ensure a competent, caring, and qualified teacher for every child.* New York: National Commission on Teaching and America's Future.

Darling-Hammond, L. (2000a). Teacher quality and student achievement: A review of state policy evidence. *Education Policy Analysis Archives, 8*(1).

Darling-Hammond, L. (2000b). Reforming teacher preparation and licensing: Debating the evidence. *Teachers College Record, 102, (1*), 28-56.

Darling-Hammond, L. (2002, September 6). Research and rhetoric on teacher certification: A response to "Teacher Certification Reconsidered*," Education Policy Analysis Archives, 10*(36). Retrieved September 2002 from //epaa.asu.edu/epaa/v10n36.html.

Darling-Hammond, L., & Ball, D. L. (1997). *Teaching for high standards: What policymakers need to know and be able to do.* Washington, DC: National Education Goals Panel.

Darling-Hammond, L., Berry, B., & Thoreson, A. (2001). Does teacher certification matter?: Evaluating the evidence. *Educational Evaluation and Policy Analysis Archives, 23*(1), 57-77.

Denton, J. & Lacina, L. (1982). Quantity of professional education coursework linked with process measures of student teaching. *Teacher Education and Practice, (1),* 39-46.

Erekson, T. & Barr, L. (1985). Alternative credentialing: Lessons from vocational education. *Journal of Teacher Education 36*(3), 16-19.

Evertson, C. M., Hawley, W. D. & Zlotnik, M. (1985). Making a difference in educational quality through teacher education. *Journal of Teacher Education 36*(3), 2-12.

Feistritzer, E. (1999a). *Teacher Quality and Alternative Certification Programs*. Washington, DC: The National Center for Education Information.

Feistritzer, E. (1999b). *The making of a teacher: A report on teacher preparation in the U.S.* Washington, DC: The National Center for Education Information.

Feistritzer, E. (2001). *Alternative teacher certification: An overview.* Washington, DC: The National Center for Education Information.

Fetler, Mark. (1999). High School staff characteristics and mathematics test results. *Education Policy Analysis Archives*. *7*(9). Retrieved on September 15, 2002 from: http://epaa.asu.edu/epaa/v7n9.html.

Focus on Teaching Quality. (2001, August). *Facts to consider about teach for America: An evaluation of teacher differences and student outcomes in Houston, Texas.* Bulletin from the electronic newsletter of the National Commission on Teaching and America's Future. Retrieved on January 25, 2003 from: http://www.nctaf.org/publications/FocusBulletin_Aug2001.htm.

Franklin, B. J., Crone, L. J. (1992, November). *School accountability: Predictors and indicators of Louisiana school effectiveness.* Paper presented at the annual meeting of the Mid-South Educational Association, Knoxville, TN.

Gallagher, H. A. (2002). *The relationship between measures of teacher quality and student achievement: The case of Vaughn elementary (California)* [CD-ROM]. Abstract from: ProQuest File: Dissertation Abstracts Item: 3060526

Goldhaber, D. D. & Brewer, D. J. (1996). *Why don't schools and teacher seem to matter? Assessing the impact of unobservables on educational productivity.*

(Report No. NCES-2000-050). Washington, DC: National Center for Education Statistics. (ERIC Document Reproduction Service No. ED 400 237)

Goldhaber, D. D. & Brewer, D. J. (1997). *Evaluating the effect of teacher degree level on educational performances.* (Report No. BBB22888). Rockville, MD: Westat, Inc. (ERIC Document Reproduction Service No. ED 406 400)

Goldhaber, D. D. & Brewer, D. J. (1999a). A three-way error components analysis of educational productivity. *Education Economics, 7*(3), 199-208.

Goldhaber, D. D. & Brewer, D. J. (1999b). Teacher licensing and student achievement. In M. Kanstoroom & C.E. Finn (Eds.), *Better teachers, better schools*. Washington, DC: Thomas B. Fordham Foundation.

Goldhaber, D. D. & Brewer, D. J. (2000). Does certification matter? High school teacher certification status and student achievement. *Education Evaluation and Policy Analysis, 22*(2), 129-145.

Hanson, J. & Feldhusen, J. (1994). Comparison of trained and untrained teachers of gifted students. *Gifted Child Quarterly 38*(3), 115-23.

Harpole, S. H., Gifford, V., Hardley, H. (1986, November). *An analysis of factors contributing to the achievement in physics of secondary students in Mississippi schools.* Paper presented at the annual meeting of the Mid-South Education Research Association, Memphis, TN.

Hawk, P. P., Coble, C. R. & Swanson, M. (1985). Certification: It does matter. *Journal of Teacher Education, 36*(3), 13-15.

Hedges, L. V., & Becker, B. J. (1986). Statistical methods in the meta-analysis of research on gender differences. In J. S. Hyde & M. C. Linn (Eds.), *The Psychology of gender: Advances through meta-analysis* (pp. 14-50). Baltimore, MD: Johns Hopkins University Press.

Hedges, L. V. & Olkin, I. (1985). *Statistical methods for meta-analysis*. Orlando, FL: Academic Press.

Huguenard, T. L. (1992). *The relationship between teacher efficacy, certification and student achievement* [CD-ROM]. Abstract from: ProQuest File: Dissertation Abstracts Item: 9313224

Hunt, M. M. (1999). *How science takes stock: The story of meta-analysis*. New York, NY: Russell Sage Foundation.

Hunter, J. E., Schmidt, F. L. (1990). *Methods of meta-analysis: Correcting error and bias in research findings.* Newbury Park, CA: Sage Publications.

Hunter, J. E., Schmidt, F. L, & Jackson, G. B. (1982). *Meta-analysis: Cumulating research findings across studies.* Beverly Hills, CA: Sage Publications.

Ingersoll, R. M. (1996). *Teacher quality and inequality*. Paper presented at the annual meeting of the American Statistical Association, Chicago, IL.

Isbell, L. L. (2000). *Teacher certification and teacher efficacy as correlates of student achievement* [CD-ROM]. Abstract from: ProQuest File: Dissertation Abstracts Item: 3054875

Laczko-Kerr, I. I. (2002). *Teacher certification does matter: The effects of certification status on student achievement* [CD-ROM]. Abstract from: ProQuest File: Dissertation Abstracts Item: 3045652

Laczko-Kerr, I. & Berliner, D. C. (2002, September 6). *The effectiveness of "Teach for America" and other under-certified teachers on student academic achievement: A case of harmful public policy*. Education Policy Analysis Archives, 10(37). Retrieved September, 2002 from http://epaa.asu.edu/epaa/v10n37/.

Light, R. J., & Pillemer, D. B. (1984). *Summing up: The science of reviewing research.* Cambridge, MA: Harvard University Press.

Lipsey, M. W., & Wilson, D. B. (2001). *Practical meta-analysis*. Thousand Oaks, CA: Sage Publications.

Lockheed, M. E. & Komenan, A. (1989). Teaching quality and student achievement in Africa: The case of Nigeria and Swaziland. *Teaching and Teacher Education, 5*(2), 93-113.

McNamara, J. F., Morales, P., Kim, Y., & McNamara, M. (1998). Conducting your first meta-analysis: An illustrated guide. *International Journal of Educational Reform, 7,* 380-397.

New York City Board of Education, Division of Assessment and Accountability. (October 10, 2000). *The impact of teacher certification on reading and mathematics performance in elementary and middle schools in New York City.* Flash research report #2. New York, NY: Author.

Peck, Hugh. (1989, March). *The effect of certification status on the performance of mathematics teachers: A pilot study.* Paper presented at the annual conference of the American Educational Research Association, San Francisco, CA.

Ponders, V.E. (2001). *The influence of teacher characteristics and preparation on student achievement in publicly funded Detroit schools (Michigan)* [CD-ROM]. Abstract from: ProQuest File: Dissertation Abstracts Item: 3001031

Roth, D. & Swail, W. S. (2000, November). *Certification and Teacher Preparation in the United States*. Pacific Resources for Education and Learning. Retrieved on May 3, 2003 from: http://www.prel.org/../products/Products/Certification-Teacher.htm.

Sander, W. & Horn, S. (1998). Research findings from the Tennessee Value-Added System Database: Implications for education evaluation and research. *Journal of Personnel Evaluation in Education. 12*(3), 247-256.

Stoddart, T. & Floden, R. E. (1995). *Traditional and alternative routes to teacher certification: Issues, assumptions and misconceptions*. Washington, DC: The National Center for Research on Teacher Learning.

Sullivan, Cheryl C. (2001). *Into the classroom: Teacher preparation, licensure, and recruitment. Elements of teacher effectiveness.* (Report No. BBB23035). Alexandria, VA: National School Boards Association. (ERIC Document Reproduction Service No. ED 460 109).

U.S. Department of Education, National Center for Education Statistics. (1999). *Teacher quality: A report on the preparation and qualifications of public school teachers.* (NCES 1999-080). Washington, DC: Author.

U.S. Department of Education, Office of Postsecondary Education, Office of Policy Planning and Innovation. (2002). *Meeting the highly qualified teachers challenge: The secretary's annual report on teacher quality.* Washington, DC: Author.

Walsh, K. (2001). *Teacher certification reconsidered: Stumbling for quality*. Baltimore, MD: The Abell Foundation.

Zirkle, J. E. (1998). *The effects of teacher certification on student achievement of music instruction goals and objectives.* Unpublished master's thesis, Salem-Teikyo University, WV.

APPENDIX A

STUDY ONE

Purpose

The purpose of study one is to explore whether students taught by teachers with standard certification have higher mathematics achievement scores than students taught by teachers with probationary, emergency or no certification in mathematics.

Independent Variable

The independent variable utilized in the study includes teachers holding the following types of certification in mathematics: (a) standard certification, (b) probationary certification, (c) emergency certification, or (d) no certification. Each type of certification listed above refers to certification in mathematics.

Teachers who hold a standard or regular certificate are regarded as fully certified and have completed all requirements designated by the state. Probationary certificates refer to teachers who have satisfied all requirements except the completion of a probationary period. Teachers holding emergency permits must complete additional coursework before they can be issued a standard certificate. Teachers who are not certified do not fall into any of the above categories. However, teachers designated as not certified, may actually not be certified in their subject area.

Four sets of additional variables include individual and family background variables, school variables, teacher variables, and class variables.

Dependent Variable

The study utilized student achievement scores taken from the National Educational Longitudinal Survey (NELS). The continuous dependent variable reflects the gain in mathematics achievement scores from tenth to twelfth grade.

Research Design

To determine whether student achievement was randomly distributed across teachers by type of certification, the dichotomous variable, standard certification, was regressed on student tenth grade achievement scores. The results indicated that students with lower tenth grade achievement levels are more likely to be assigned a teacher without standard certification than students with higher ability levels.

To explore the effect of certification type on student achievement, student twelfth grade achievement scores were regressed on teacher variables that include certification type as well as on three additional sets of individual and family variables, school variables and class variables.

The calculation of effect sizes are based on descriptive statistics such as the mean, standard deviation and number of observations associated with each certification category. The effect sizes reported for mathematics and science did not utilize input data resulting from regression procedures. Accordingly, the effect sizes do not reflect the effects of individual and family background variables, school variables, teacher variables, and class variables.

Comments on the Research Design

The regression procedures used in the study provide information on the degree to which certification status affects student achievement from tenth to twelfth grade. The differences in achievement reflect the effect of certification after individual and family variables, school variables and class variables have been taken into account. Therefore, the results of the study provide a comprehensive picture of the forces involved with student achievement.

Although the results of a regression analysis indicated that tenth grade scores were not equally distributed across certification types, it is unclear how this was finding was addressed in subsequent regression procedures. It appears that twelfth grade scores were regressed on sets of variables that did not

include tenth grade test scores. Not controlling for the influence of student ability on achievement scores obscures the effect of certification and interferes with the interpretation of results.

Another issue surrounding the interpretation of results has to do with the composition of the certification categories. For example, teachers designated as not having certification include teachers who are not certified and teachers who hold certification in another subject. The relatively low levels of achievement associated with this category may actually be lower for teachers who are not certified in any subject. Conversely, certification in another subject may yield equally low achievement or possibly higher student achievement.

Mathematics Effect Size Indicators

Standard Certification and Probationary Certification

$$S_d = \frac{3179(5.36^2) + 24(3.54^2)}{3179 + 24 - 2} = \frac{91331.40 + 300.76}{3201} = \frac{91632.16}{3201} = 28.63^{1/2} = 5.35$$

$g = 5.05 - 6.51 = -1.460/5.35 = -0.273$

$c = 1 - \frac{3}{4(3179) + 4(24) - 9} = 1 - \frac{3}{12803} = 1 - 0.0002 = 0.999$

$d = -0.273(0.999) = -0.273$

$$v = \frac{3179 + 24}{3179(24)} + \frac{-0.273^2}{2(3203)} = \frac{3203}{76296} + \frac{0.074}{6406} = 0.042 + 0.000 = 0.042^{1/2} = 0.205$$

$CI_{95} = -0.273 - 1.96(0.205) < d < -0.273 + 1.96(0.205)$ (ME = 0.402)

$= -0.273 - 0.402 < d < 0.402 + -0.273$

$= -0.674 < d < 0.129$

Standard Certification and Emergency Certification

$$S_d = \frac{3179(5.36^2) + 49(5.12^2)}{3179 + 49 - 2} = \frac{91331.40 + 1284.51}{3226} = \frac{92615.90}{3226} = 28.71^{1/2} = 5.36$$

$g = 5.05 - 5.80 = -0.750/5.36 = -0.140$

$c = 1 - \frac{3}{4(3179) + 4(49) - 9} = 1 - \frac{3}{12903} = 1 - 0.0002 = 0.999$

$d = -0.140(0.999) = -0.140$

$$v = \frac{3179 + 49}{3179(49)} + \frac{-0.140^2}{2(3228)} = \frac{3228}{155771} + \frac{0.074}{6456} = 0.021 + 0.000 = 0.021^{1/2} = 0.144$$

$CI_{95} = -0.140 - 1.96(0.144) < d < -0.140 + 1.96(0.144)$ (ME = 0.282)

$= -0.140 - 0.282 < d < -0.140 + 0.282$

$= -0.422 < d < 0.142$

Standard Certification and No Certification

$$S_d = \frac{3179(5.36^2) + 77(4.68^2)}{3179 + 77 - 2} = \frac{91331.40 + 1686.48}{3254} = \frac{93017.88}{3254} = 28.59^{1/2} = 5.35$$

$g = 5.05 - 3.59 = 1.46/5.35 = 0.273$

$$c = 1 - \frac{3}{4(3179) + 4(77) - 9} = 1 - \frac{3}{13015} = 1 - 0.0002 = 0.999$$

$d = 0.273(0.999) = .273$

$$v = \frac{3179 + 77}{3179(77)} + \frac{0.273^2}{2(3256)} = \frac{3256}{244783} + \frac{0.075}{6512} = 0.013 + 0.000 = 0.013^{1/2} = 0.115$$

$CI_{95} = 0.273 - 1.96(0.115) < d < 0.273 + 1.96(0.115)$ (ME = 0.226)
$= 0.273 - 0.226 < d < 0.273 + 0.226$
$= 0.047 < d < 0.499$

Science Effect Size Indicators
Standard Certification and Probationary Certification

$$S_d = \frac{2069(3.71^2) + 41(3.53^2)}{2069 + 41 - 2} = \frac{28477.92 + 510.90}{2108} = \frac{28988.82}{2108} = 13.75^{1/2} = 3.71$$

$g = 1.87 - 1.12 = 0.750/3.71 = 0.202$

$$c = 1 - \frac{3}{4(2069) + 4(41) - 9} = 1 - \frac{3}{8440} = 1 - 0.0004 = 0.999$$

$d = 0.202(0.999) = -0.202$

$$v = \frac{2069 + 41}{2069(41)} + \frac{0.202^2}{2(2110)} = \frac{2110}{84829} + \frac{0.041}{4220} = 0.025 + 0.000 = 0.025^{1/2} = 0.158$$

$CI_{95} = 0.202 - 1.96(0.158) < d < 0.202 + 1.96(0.158)$ (ME = 0.309)
$= 0.202 - 0.309 < d < 0.202 + 0.309$
$= -0.107 < d < 0.511$

Standard Certification and Emergency Certification

$$S_d = \frac{2069(3.71^2) + 41(3.58^2)}{2069 + 41 - 2} = \frac{28477.92 + 525.47}{2108} = \frac{29003.39}{2108} = 13.76^{1/2} = 3.71$$

$$g = 1.87 - 2.68 = -0.810/3.71 = -0.218$$

$$c = 1 - \frac{3}{4(2069) + 4(41) - 9} = 1 - \frac{3}{8440} = 1 - 0.0004 = 0.999$$

$$d = 0.202(0.999) = -0.218$$

$$v = \frac{2069 + 41}{2069(41)} + \frac{-0.218^2}{2(2110)} = \frac{2110}{84829} + \frac{0.048}{4220} = 0.025 + 0.000 = 0.025^{1/2} = 0.158$$

$CI_{95} = -0.218 - 1.96(0.158) < d < -0.218 + 1.96(0.158)$ (ME = 0.309)
$= -0.218 - 0.309 < d < -0.218 + 0.309$
$= -0.527 < d < 0.091$

Standard Certification and No Certification

$$S_d = \frac{2069(3.71^2) + 29(3.47^2)}{2069 + 29 - 2} = \frac{28477.92 + 349.19}{2096} = \frac{28827.11}{2096} = 13.75^{1/2} = 3.71$$

$$g = 1.87 - 1.74 = .130/3.71 = 0.035$$

$$c = 1 - \frac{3}{4(2069) + 4(29) - 9} = 1 - \frac{3}{8392} = 1 - 0.000 = 0.999$$

$$d = 0.035(0.999) = 0.035$$

$$v = \frac{2069 + 29}{2069(29)} + \frac{0.035^2}{2(2098)} = \frac{2098}{60001} + \frac{0.001}{4196} = 0.035 + 0.000 = 0.035^{1/2} = 0.187$$

$CI_{95} = 0.035 - 1.96(0.187) < d < 0.035 + 1.96(0.187)$ (ME = 0.367)
$= 0.035 - 0.367 < d < 0.035 + 0.367$
$= -0.331 < d < 0.402$

APPENDIX B

STUDY TWO

Purpose

Study two examined whether mathematics achievement differed for students taught by teachers certified in mathematics or certified in a field other than mathematics. The study utilized two levels of mathematics classes that include (a) general mathematics and (b) algebra.

Independent Variable

The dichotomous independent variable utilized in the study includes teachers holding either (a) certification in mathematics or (b) certification in a field other than mathematics. Of the thirty-six teachers involved in the study, eighteen were certified in mathematics and eighteen were certified out-of-field.

Dependent Variable

In both general mathematics and algebra, the dependent variable was the achievement scores of students taught by either teachers, certified in each field or certified in a field other than mathematics. In general mathematics, the dependent variable consisted of achievement scores for 286 middle school students taught by teachers certified in the field and 283 middle school students of teachers certified out-of-field. In algebra, the dependent variable included achievement scores for 28 high school students taught by teachers certified in algebra and 16 high school students of teachers certified out-of-field.

Research Design

The study utilizes a pretest/posttest design where teachers were matched on key variables to control the influence of the particular school, the specific mathematics class and any pre-existing differences in student achievement. Teachers were therefore matched according to three characteristics: (a) All teachers taught in the same school, and (b) taught the same mathematics course to, (c) students of equivalent ability level. Student posttest scores in general mathematics and algebra classes were compared after five months of instruction.

Comments on the Research Design

The strength of this study rests with the matched pair design where students of each group of teachers were paired according to ability level. With this design, it is possible to attribute differences in performance to the quality of instruction and to rule out any pre-existing advantages in ability. Similarly, the effect of the particular school on student achievement was addressed by pairing teachers within schools instead of across schools. In this way, differences in achievement for each group of teachers cannot be attributed to the effect of one school over another. However, the authors did not report on the number of schools involved or on their characteristics. Results of this study may therefore be specific to the particular socioeconomic or demographic characteristics of the schools used in the study.

t test for pre-test means

General Mathematics

$$S_d = \frac{285(8.69^2) + 282(7.87^2)}{286 + 283 - 2}$$

$$= \frac{21522.1 + 17466.2}{567}$$

$$= \frac{38988.3}{567}$$

$$= 68.76^{1/2} = 8.29$$

$$g = 23.93 - 22.00 = 1.93/8.29 = 0.233$$

Algebra

$$S_d = \frac{27(6.25^2) + 15(6.12^2)}{28 + 16 - 2}$$

$$= \frac{1054.6 + 561.8}{42}$$

$$= \frac{1616.44}{42}$$

$$= 38.48^{1/2} = 6.20$$

$$g = 20.21 - 23.25 = -3.04/6.20 = -0.490$$

Effect Size Indicators
General mathematics

$$S_d = \frac{285(8.75^2) + 283(8.14^2)}{286 + 283 - 2}$$

$$= \frac{21820.3 + 18751.5}{567}$$

$$= \frac{40571.76}{567}$$

$$= 71.55^{1/2} = 8.45$$

$$g = 27.14 - 23.98 = 3.16/8.46 = 0.374$$

$$c = 1 - \frac{3}{4(286) + 4(283) - 9}$$

$$= 1 - \frac{3}{2267}$$

$$= 1 - 0.001 = 0.998$$

$$d = 0.374(0.988) = 0.373$$

$$v = \frac{286 + 283}{286(283)} + \frac{.374^2}{2(286 + 283)}$$

$$= \frac{569}{80938} + \frac{0.1398}{1138}$$

$$= 0.007 + 0.000 = 0.007$$

$$= 0.007^{1/2} = 0.084$$

$CI_{95} = 0.373 - 1.96(0.084) < d < 0.373 + 1.96(0.084)$ (ME = 0.166)
$= 0.373 - 0.166 < d < 0.373 + 0.166$
$= 0.207 < d < 0.538$

Effect Size Indicators
Algebra

$S_d = \frac{27(6.75^2) + 15(6.72^2)}{28 + 16 - 2}$

$= \frac{1230.2 + 677.4}{42}$

$= \frac{1907.6}{42}$

$= 45.42^{1/2} = 6.74$

$g = 25.54 - 24.37 = 1.17/6.74 = .17$

$c = 1 - \frac{3}{4(28) + 4(16) - 9}$

$= 1 - \frac{3}{167}$

$= 1 - 0.018 = 0.982$

$d = 0.17(0.982) = 0.167$

$v = \frac{28 + 16}{28(16)} + \frac{.17^2}{2(28 + 16)}$

$= \frac{44}{448} + \frac{0.029}{88}$

$= 0.098 + 0.001 = 0.098$

$= 0.098^{1/2} = 0.31$

$CI_{95} = 0.167 - 1.96(0.31) < d < 0.167 + 1.96(0.31)$ (ME = 0.607)
$= 0.167 - 0.607 < d < 0.167 + 0.607$
$= 0.44 < d < 1.21$

APPENDIX C

STUDY THREE

Purpose

The purpose of the study was to compare the achievement of students taught by regularly certified teachers to the achievement of students taught by under-certified teachers.

Independent Variable

The initial independent variable utilized in the study consisted of teachers who had one of the following types of certification: (a) full state certification, (b) emergency certification, (c) temporary certification, or (d) provisional certification. The latter three groups were combined to form one group of under-certified teachers after results of a one-way analysis of variance (ANOVA) conducted by the authors revealed that mean scores were not statistically different. The independent variable herein refers to teachers who are either: (a) fully certified, or (b) under-certified.

Dependent Variable

The study utilized two separate years of student test scores in mathematics. Individual level student scores were aggregated at the class level to yield an average achievement score for each teacher involved in the study. The raw data therefore consisted of class-level means reported in normal curve equivalent scores (NCE).

In order to examine the effect of non-compartmentalized classrooms on mathematics achievement, class-level mean scores for grades three through eight and grades three through six were analyzed separately. However, in lieu of reporting separate results for grades three through six, the authors provide general information on the statistical significance of these analyses. Therefore, the dependent variable herein refers to class-level mean achievement scores in grades three through eight for two separate years.

Research Design

The study utilized 293 recently-hired teachers from five low-income school districts. Certified and under-certified teachers were matched according to similar school and district characteristics. This design strategy is intended to control for the effect of a school or district on student achievement scores.

One-way analysis of variance (ANOVA) procedures were conducted at the school and district level to determine whether pre-existing differences in mean achievement scores were present in matched pairs of teachers or within the two teacher groups. The effect of certification on student achievement was examined by comparing class-level scores for pairs of certified and under-certified teachers.

Comments on the Research Design

The authors conducted one-way analysis of variance (ANOVA) procedures at the school and district level to examine whether differences in mean achievement were evident in matched pairs of fully certified and under-certified teachers. The results of several of these procedures are described below.

1. In data set one, mean student scores for certified and under-certified teachers were statistically different in at least one school.
2. In both data set one and two, mean mathematics scores for certified and under-certified teachers were statistically different in at least one district.
3. In data set one, a comparison of under-certified teachers matched either within the same district or between districts indicated that mean scores were significantly different in at least one district.

Given that the purpose of the matched-pair design is to yield equivalent groups the findings described above suggest that school and district effects may account for some of the differences observed in certification status.

Mathematics Effect Size Indicators
Data Set One

$S_d = \frac{28(8.77^2) + 28(7.32^2)}{28 + 28 - 2}$ $g = 38.80 - 35.82 = 2.98/8.23 = .362$ $v = \frac{28 + 28}{28(28)} + \frac{0.362^2}{2(28 + 28)}$

$= \frac{2153.56 + 1500.31}{54}$ $c = 1 - \frac{3}{4(28) + 4(28) - 9}$ $= \frac{56}{784} + \frac{0.131}{112}$

$= \frac{3653.87}{54}$ $= 1 - \frac{3}{224}$ $= 0.071 + 0.001$

$= 67.66^{1/2} = 8.23$ $= 1 - 0.014 = 0.986$ $= 0.073^{1/2} = 0.269$

$d = 0.362(0.986) = 0.357$

$CI_{95} = 0.357 - 1.96(0.269) < d < 0.357 + 1.96(0.269)$ (ME = 0.528)
$= 0.357 - 0.528 < d < 0.357 + 0.528$
$= -0.171 < d < 0.885$

Data Set Two

$S_d = \frac{87(9.52^2) + 87(9.77^2)}{87 + 87 - 2}$ $g = 39.75 - 35.22 = 4.53/9.70 = .467$ $v = \frac{87 + 87}{87(87)} + \frac{0.362^2}{2(28 + 28)}$

$= \frac{7884.84 + 8304.40}{172}$ $c = 1 - \frac{3}{4(87) + 4(87) - 9}$ $= \frac{174}{7569} + \frac{0.218}{348}$

$= \frac{16189.25}{172}$ $= 1 - \frac{3}{687}$ $= 0.023 + 0.006$

$= 94.12^{1/2} = 9.70$ $= 1 - 0.004 = 0.995$ $= 0.024^{1/2} = 0.154$

$d = 0.467(0.995) = 0.465$

$CI_{95} = 0.465 - 1.96(0.154) < d < 0.465 + 1.96(0.154)$ (ME = 0.301)
$= 0.465 - 0.301 < d < 0.465 + 0.301$
$= 0.164 < d < 0.766$

Combined Estimator for Mathematics

$d_. = \frac{\Sigma w_i d_i}{w_i}$ $\quad d_. = \frac{14.0}{57.5}\ 0.362 + \frac{43.5}{57.5}\ 0.465$ $\quad v_. = \frac{1}{\Sigma\, w_i} = \frac{1}{57.5} = 0.017$

$w_1 = \frac{1}{v_1} = \frac{2}{28} = 14.0$ $\quad d_. = 0.44$ $\quad v_.^{1/2} = 0.132$

$w_2 = \frac{1}{v_1} = \frac{2}{87} = 43.5$

$\Sigma\, w_i = 57.5$

$CI_{95} = 0.44 - 1.96(0.132) < d < 0.44 + 1.96(0.132)$ (ME = 0.26)
$= 0.18 < d < 0.70$

Reading Effect Size Indicators
Dataset One

$S_d = \frac{28(9.59^2) + 28(8.02^2)}{28 + 28 - 2}$ $\quad g = 36.52 - 30.67/9.00 = 0.650$ $\quad v = \frac{28 + 28}{28(28)} + \frac{0.641^2}{2(28 + 28)}$

$= \frac{2575.11 + 1800.97}{54}$ $\quad c = 1 - \frac{3}{4(28) + 4(28) - 9}$ $\quad = \frac{56}{784} + \frac{0.422}{112}$

$= \frac{4376.08}{54}$ $\quad = 1 - \frac{3}{224}$ $\quad = 0.071 + 0.003$

$= 81.04^{1/2} = 9.00$ $\quad d = 0.650(0.986) = 0.641$ $\quad = 0.075^{1/2} = 0.274$

$= 1 - 0.014 = 0.986$

$CI_{95} = 0.641 - 1.96(0.274) < d < 0.641 + 1.96(0.274)$ (ME = 0.537)
$= 0.641 - 0.537 < d < 0.641 + 0.537$
$= 0.103 < d < 1.178$

Dataset Two

$S_d = \frac{87(9.31^2) + 87(9.43^2)}{87 + 87 - 2}$ $g = 35.62 - 32.48 = 3.14/9.42 = 0.333$ $v = \frac{87 + 87}{87(87)} + \frac{0.332^2}{2(28 + 28)}$

$= \frac{7540.82 + 7736.47}{172}$ $c = 1 - \frac{3}{4(87) + 4(87) - 9}$ $= \frac{174}{7569} + \frac{0.111}{348}$

$= \frac{15277.29}{172}$ $= 1 - \frac{3}{687}$ $= 0.023 + 0.003$

$= 1 - 0.004 = 0.995$ $= 0.023^{1/2} = 0.153$

$= 88.82^{1/2} = 9.42$ $d = 0.333(0.995) = 0.332$

$CI_{95} = 0.332 - 1.96(0.153) < d < 0.332 + 1.96(0.153)$ (ME = 0.299)
$= 0.332 - 0.299 < d < 0.332 + 0.299$
$= 0.032 < d < 0.637$

Combined Estimator for Reading

$d. = \frac{\Sigma w_i d_i}{w_i}$ $d. = \frac{14.0}{57.5}\ 0.362 + \frac{43.5}{57.5}\ 0.465$ $v. = \frac{1}{\Sigma w_i} = \frac{1}{57.5} = 0.017$

$w_1 = \frac{1}{v_1} = \frac{2}{28} = 14.0$ $d. = 0.44$ $v.^{1/2} = 0.132$

$w_2 = \frac{1}{v_1} = \frac{2}{87} = 43.5$

$\Sigma w_i = 57.5$

$CI_{95} = 0.44 - 1.96(0.132) < d < 0.44 + 1.96(0.132)$ (ME = 0.26)
$= 0.18 < d < 0.70$

APPENDIX D

STUDY FOUR

Purpose

The purpose the study is to investigate whether the percent of teachers with full state certification and the percent of teachers certified out-of-field, influence state-level National Assessment of Educational Progress (NAEP) student achievement scores.

Independent Variable

For each of the four datasets, the following continuous independent variables were used in a regression analysis. All variables are state-level average proportions and are defined as follows:

1. Class size.
2. Poverty refers to the percent of students with incomes blow the poverty line.
3. LEP refers to the percent of students who are limited English proficient.
4. "Well-qualified" teachers refer to the percent with full state certification that have either an undergraduate major or master degree in the field taught. For elementary teachers, the equivalent of a major is an elementary education degree for generalists who teach multiple subjects to the same group of students. (Darling-Hammond, 2000a, pg 25)
5. "Newly-hired uncertified" teachers refer to the percent of newly hired teachers who are uncertified in their main teaching assignment.

Ten variables were correlated with state-level average achievement. All variables are state-level average proportions and are defined as follows:

1. Well-qualified teachers.
2. Newly-hired uncertified teachers.
3. "Out-of-field" teachers refer to those with less than a minor in the field they teach.
4. "Fully certified" includes teachers with standard or regular certification and new teachers on probationary certificates who have completed all requirements for a license except for the completion of the probationary period (usually two or three of beginning teaching." (Darling-Hammond, 2000a, pg 25)
5. "Less-than-fully certified" includes teacher with no certificate and those with provisional, temporary, or emergency certification." (Darling-Hammond, 2000a, pg 25)
6. New entrants to teaching who are uncertified.
7. Newly-hired uncertified teachers.
8. Per pupil spending
9. Pupil to teacher ratio
10. Class size.

Dependent Variable

The study utilized state-level student NAEP scores in mathematics. The dependent variable consisted of two groups of state-level mean scores for fourth grade that included 1992 and 1996, and two groups of state-level mean scores for eighth grade that included 1990 and 1996.

Research Design

A regression analysis was used to examine the effect of a series of teacher and student variables on state-level mean NAEP scores.

APPENDIX E

STUDY FIVE

Purpose

The purpose the study is to investigate the relationship between indices of teacher skill and preparation including the proportion of teachers with emergency permits and three grade levels of school-level student achievement scores.

Independent Variable

Five independent variables were used to investigate the role of teacher certification on student achievement. The independent variables are defined as follows:

1. The percent of mathematics teachers with emergency permits. Emergency permits refer to teachers who have (a) a Bachelor's degree, (b) passed a basic skills test, and (c) completed a minimum of 18 semester hours or 9 upper division/graduate semester units of course work in mathematics. "Emergency permits are used to hire individuals who lack some requirements for a certificate, usually proof of competence in their subject of instruction or pedagogy." (pg 5)
2. Teacher's educational degree include the following categories: (a) Doctorate, (b) Master's degree plus 30 or more semester hours, (c) Master's degree, (d) Bachelor's degree plus 30 or more semester hours, (e) Bachelor's degree..
3. Number of years teaching.
4. Participation refers to the percent of total students enrolled that participated in the achievement assessment.
5. Percent of students in a schools attendance area who are from families receiving aid (AFDC). This variable serves as a measure of student poverty.

Dependent Variable

The dependent variable utilized in the study was school-level mean test scores for the mathematics portion of the Stanford Achievement Test Series, Ninth Edition
(SAT9).

Research Design

For each grade, the five independent variables described above were correlated with corresponding school-level mean test scores. Separate multiple regression procedures were also conducted for each grade in which school-level mean test scores were regressed on the five independent variables.

The three effect size indicators reported for each grade in the synthesis of mathematics achievement are correlation coefficients. Each coefficient represents the association between achievement scores and the percent of emergency permits in a school, controlling for the effect of poverty. Study four reported similar correlations that controlled for student poverty. Therefore, in an attempt to make interpretation of effect size indictors consistent across studies four and five, the zero order correlations reported by the authors of study five were used to calculate partial correlations. Each coefficient refers to the correlation between mean school-level achievement and the percent of well-qualified teachers in a school, with the effect of student poverty removed from both variables.

Partial Correlations

Grade 9

$$r_{yz*x} = \frac{r_{y1z} - r_{xy1}(r_{xz})}{(1 - r^2_{xy1})(1 - r^2_{xz})^{1/2}}$$

$$\frac{-0.306 - -0.618\ (0.195)}{(1 - -0.618)(1 - 0.195)^{1/2}}$$

$$\frac{-0.1855}{(0.617)(0.962)^{1/2}}$$

$$\frac{-0.185}{0.770} = -0.241$$

Grade 10

$$r_{yz*x} = \frac{r_{y2z} - r_{xy2}(r_{xz})}{(1 - r^2_{xy2})(1 - r^2_{xz})^{1/2}}$$

$$\frac{-0.285 - -0.586\ (0.195)}{(1 - -0.586)(1 - 0.195)^{1/2}}$$

$$\frac{-0.171}{(0.656)(0.962)^{1/2}}$$

$$\frac{-0.171}{0.794} = -0.215$$

Grade 11

$$r_{yz*x} = \frac{r_{y3z} - r_{xy3}(r_{xz})}{(1 - r^2_{xy3})(1 - r^2_{xz})^{1/2}}$$

$$\frac{-0.302 - -0.583\ (0.195)}{(1 - -0.583)(1 - 0.195)^{1/2}}$$

$$\frac{-0.188}{(0.659)(0.962)^{1/2}}$$

$$\frac{-0.188}{0.796} = -0.236$$

x = Student poverty
z = Percent of teachers with emergency permits for each grade
$y_1 = 9^{th}$ grade test score
$y_2 = 10^{th}$ grade test score
$y_3 = 11^{th}$ grade test score

Tests of Significance for Partial Correlations

Grade 9

$$t = -0.241\sqrt{\frac{690 - 2}{1 - -0.241^2}}$$

$-6.51 > -1.96$*

Grade 10

$$t = -0.215\sqrt{\frac{697 - 2}{1 - -0.215^2}}$$

$-5.80 > -1.96$*

Grade 11

$$t = -0.236\sqrt{\frac{703 - 2}{1 - -0.236^2}}$$

$-6.44 > -1.96$*

* Critical value for two tailed test

VITA

Karin Sparks

Current Address

708 East 27th Street
Bryan, Texas 77803
karinsparks@neo.tamu.edu

Education

B.A. University of New Mexico, 1984
Major: History
Minor: Psychology

M.S. Texas A&M University, 1999
Major: Educational Psychology
Specialty Track: Research, Measurement & Statistics

Ph.D.
Texas A&M University, 2004
Major: Educational Psychology
Specialty Track: Research, Measurement & Statistics

Experience

- Institute for School – University Partnerships (TAMUS)
  Senior Research Associate

- Public Policy Research Institute (PPRI), Texas A&M University
  GraduateAssistant

- Educational Research and Evaluation Laboratory, College of Education, (TAMU)
  GraduateAssistant

- ACT, Iowa City, Iowa.
  Intern.

- Psychological Corporation, Performance Assessment Scoring Center, San Antonio, Texas
  Team Leader.