An Examination of the Relationship between Teacher Quality and Student Achievement

(New Title: Teacher Effect Model for Impacting Student Achievement)

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Abstract

Research recognizes that the greatest determinate of student achievement is the teacher, yet questions remain as to what characteristics of teachers are the most influential. This paper explores the teacher effect through the evaluation of the interaction among characteristics of four teacher profiles using Surveys of Enacted Curriculum®. This Teacher Effect Model was designed to evaluate the future impacts of sustained professional development.

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Purpose

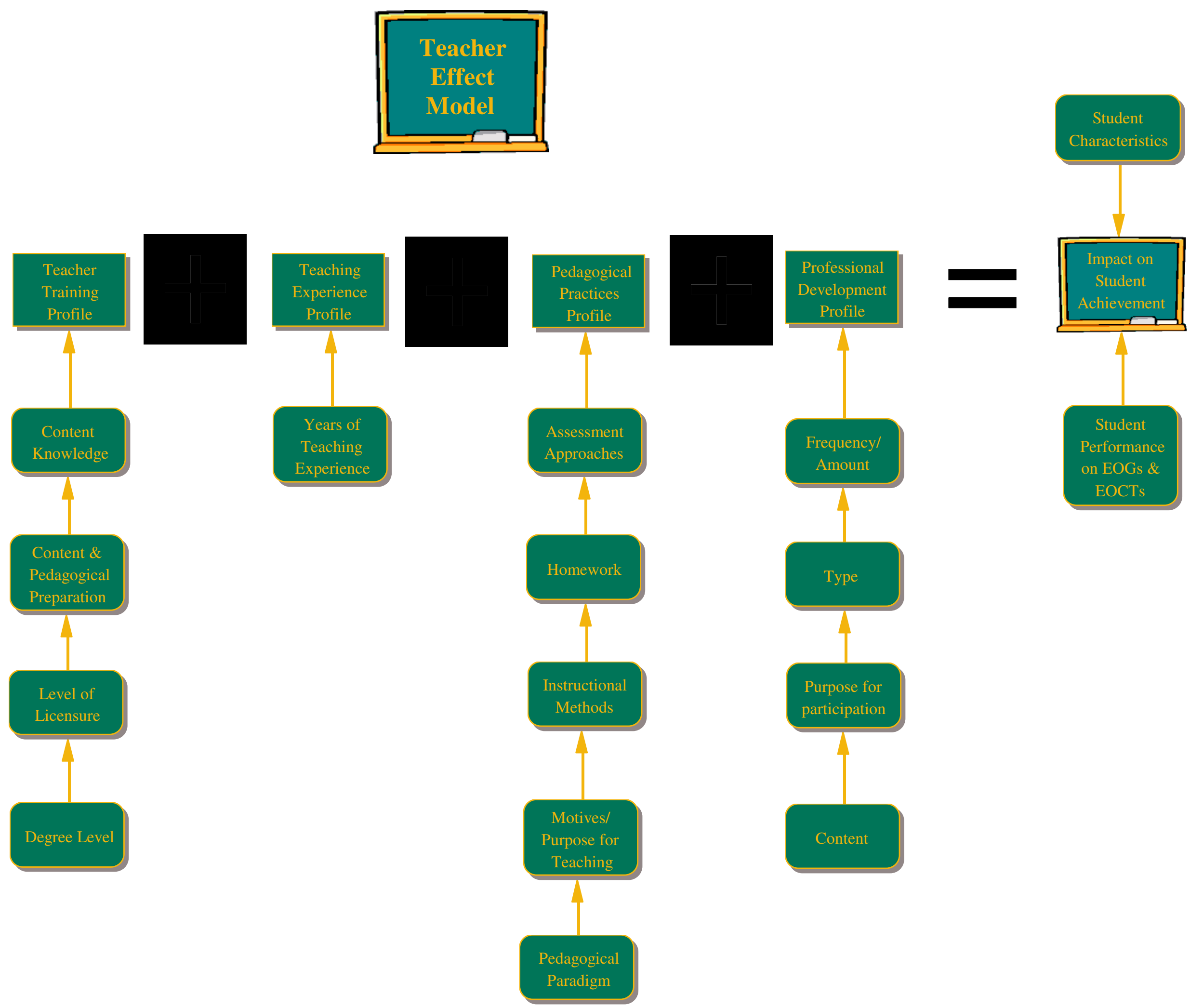
The purpose of this study was to examine the teacher effect on student achievement as defined by a composite of four teacher effect profiles. These profiles include characteristics of teachers such as: teacher training, teaching experiences, pedagogical practices, and professional development. The interaction among these characteristics were used to identify the greatest determinates of student achievement in mathematics. The model was also used to identify targeted needs for professional development based upon data from student outcomes. Math achievement was evaluated based on student performance on state-mandated standardized tests. This Teacher Effect Models provides a framework for future analyses of the impact of intervention strategies for evaluating and improving professional development.

This research is part of The North Carolina Partnership for Improving Math and Science (NC-PIMS), a five-year grant funded by the National Science Foundation and the Department of Education to improve student outcomes in Math and Science through policy, professional development, and parent programs. A cascading model of program delivery provides training to 24 facilitators, 532 lead teachers and over 6,000 classroom teachers in mathematics and science. The goal of the grant is to provide quality, comprehensive training to teachers in an effort to decrease the achievement gap in mathematics while increasing the overall outcomes for all students in the participating districts. The Teacher Effect Model is being used to determine the effectiveness of professional development offered by this NSF grant and inform and direct future professional development plans to maximize the impact of these interventions in improving student achievement.

The guiding research questions for this study are:

- What characteristics of teachers best account for student achievement?
- Are there significant differences within teacher effect profiles in determining student achievement?

The Teacher Effect Model



The Teacher Effect Model measures the impact of various characteristics of teachers and the interaction among these on student achievement.   The Teacher Effect Model is a composite of four profiles: *teacher training*, *teaching experience*, *pedagogical practices*, and *professional development*. The four profiles were selected based upon an extensive research review of the variables that affect teacher quality. The premise of this model is that teacher quality can be linked to student achievement; therefore, understanding the aspects that shape teacher quality can greatly influence interventions such as professional development in improving student learning outcomes.

The four profiles identified (teacher training, teaching experience, pedagogical practices, and professional development) are recognized as determinants of student achievement. Within each profile are attributes or characteristics of teachers that are variables that shape and define the profile. The Teacher Training Profile describes several elements that determine the quality of teacher training. These include content degree, degree level, content and pedagogical preparation, and content knowledge. The next profile is comprised of years of teaching experience. The third profile is a combination of variables that shape teachers' pedagogical practices and is the most complicated of all profiles. These variables include teachers' pedagogical paradigm [traditional or constructivist], teachers' motives or purpose for teaching, teachers' instructional methods [technology use, nature of the task {individual or collaborative}, and cognitive level of the task {Levels 1, 2, or3}], teachers' homework instructional methods [frequency, accountability, and cognitive level of the task {Levels 1, 2, 3}], and teachers' assessment approaches [traditional or constructivist]. The fourth teacher profile is the professional development profile which measures the content, purpose for participation, type, and frequency/amount of professional development training teachers have participated. The interaction between and among these four profiles are factors in determining overall student achievement. This model is designed to define profiles so that variables can be controlled; thus, changes can be measured over time. This perspective allows researchers to understand the affects of professional development and how it changes pedagogical practices.

Theoretical Framework

Research identifies many factors affecting student achievement (Zuelke, 2001); however, the greatest determinant of student achievement is the influence of teachers (Collias, Pajak, & Rigden, 2000; Lasley, Siedentop, & Yinger, 2006; Public Education Network, 2004; Sanders & Rivers, 1996). Studies have found that the majority of the difference in student tests scores can be directly attributed to teacher quality (Darling-Hammond & Ball, 1997). Thus, the impact of teachers can either be positive or negative depending on teacher quality as defined by various teacher characteristics. The effect teachers have on student achievement depends upon teacher training, teaching experience, pedagogical practices, and professional development experiences.

Teacher Training

The Elementary and Secondary Education Act or No Child Left Behind (NCLB) (2001) requires that all classrooms have a highly qualified teacher by 2005-2006. NCLB defines highly qualified as a teacher holding a bachelor's degree in any subject, full licensure or certification, and successful completion of a content knowledge test or content major. Due to the ambiguity of "highly qualified" many state have adopted definitions that equate to existing licensure requirements. This has allowed states to interpret all certified teachers as highly qualified. These expectations fall short of capturing the necessary attributes of high quality teachers.

Teacher training is not limited to an academic degree or licensure; it also includes subject-matter knowledge and content specific pedagogical preparation. As a result, a correlation exists between academic degree and licensure. An underlining expectation is that there must be compatibility between the two and one informs the other. Content knowledge and pedagogical knowledge are not mutually exclusive (Capraro, et.al., 2002; Cooney, 2003, Quinn, 1997) and are essential for building pedagogical content knowledge which greatly impacts teacher effectiveness (Smithson, Porter and Blank 2001 and 2002). Thus, teacher licensure includes rigorous content area preparation, either in the form of a degree, major, or adequate performance on a subject area test and pedagogical training relevant to the grade levels, and content of certification.

The quality of teacher training, especially in elementary and middle grades programs, has been criticized because it is believed that these programs are not adequately preparing teachers in content. Researchers tout that teacher content knowledge is sacrificed for pedagogical training and is not comparable to the depth of training of those seeking content only degrees (Ball, 1990; Rech, Hartzell, & Stephens, 1993; Tirosh & Graeber, 1989). Specific content area weaknesses are recognized in areas of math and science (Capraro, et.al., 2002). This was affirmed by Southern Regional Education Board (Cooney, 2003), in a study of fourteen states, found that the majority of K-8 teachers were lacking in the math and science content knowledge and had only received general content training as part of their elementary education degree. Most of their training focused on procedural or general pedagogy. This is of concern when research indicates that teachers' content knowledge is definitively linked to student performance (Goldhaber & Anthony, 2003; Goldhaber & Brewer, 1999; Lasley, Bainbridge, & Berry, 2002).

This concern is not limited to elementary and middle grades education, but is also an issue for secondary education. Not all programs require a content degree, but some offer instead a secondary education degree with a content focus. This is more common for content such as comprehensive science, yet it still occurs for mathematics. Monk (1994) conducted a study of approximately 3000 high school students who had taken tests in mathematics and science. Demographic information on the students was provided. The teachers of the students were then surveyed on the number of content courses they had received and their responses were correlated with student outcomes. Students whose teachers had taken a greater number of mathematics and science courses scored higher on the math and science assessments. Goldhaber and Brewer (1996), Quinn (1997), and Zuelke (2001) found similar relationships in their analysis. Quinn (1997) also reported that when teachers improved their attitudes toward math, the student achievement was impacted.

Another element of teacher training is the level of licensure that teachers have achieved. By levels of licensure, we are referring to three types of licensure. Level one is a teacher who holds an initial licensure in mathematics and has completed a four-year undergraduate degree. Level two refers to a teacher who has achieved advanced (or master's) licensure in mathematics and who has completed a master's degree. The third category of licensure identifies teachers who are national board certified. Initial or advanced licensed teachers can have this additional certification. This latter recognition of national board certification has been linked to higher performance for students (Goldhaber & Anthony, 2003; Vandevoort, Amrein-Beardsley, & Berliner, 2004). Research indicates a positive correlation of student achievement in mathematics and teacher certification (Minichello, 2004).

Teaching Experience

The second teacher variable impacting student achievement is teaching experience of teachers. Teaching experience tends to have a positive impact on student achievement. Research suggests that the more years of experience that teachers have the better students perform academically (Cooney, 2003; Goldhaber & Anthony, 2003; Lasley, Bainbridge, & Berry, 2002), yet this relationship is not always linear as the correlation between student achievement and teaching experience tends to level off with higher levels of teaching experience (Darling-Hammond, 2000). This is often a result of teacher stagnation and lack of continual learning as teachers near the end of their careers.

Specifically in mathematics, teaching experience can affect student achievement, but the level of the effect is uncertain. Despite the effects of student socio-economic status on student achievement, Felter (2001) found a positive relationship between teacher experience and preparation and student achievement in mathematics. Additionally, Kelcker (2002) found significant differences in student performance on the eighth grade 2000 National Assessment of Educational Progress (NAEP) mathematics test. This study evaluated student performance on the fourth and eighth grade NAEP mathematics test for Kentucky, Tennessee, and Texas public school students. Despite the positive influence for eighth grade students, there were no significant differences for fourth grade students. Thus

Kelcker (2002) concluded that summative scores were not conclusive evidence that teaching experience in mathematics greatly affected overall student performance.

Pedagogical Practices

Pedagogical practices of teachers do have important impact on student achievement (Frome, Lasater, & Cooney, 2005; Gales & Yan, 2001; House, 2005; Lloyd, 2001). Pedagogical practices that teachers employ in their classrooms are shaped by their pedagogical paradigm. Teachers align their instructional beliefs with either traditional or constructivist methods. Traditional approaches are grounded in behaviorist ideology and are based upon the research of Gagne (1985). Learning is viewed as cumulative and requires structured knowledge and skill development. Knowledge is presented as a sequential process with absolute outcomes (e.g. a correct answer to a mathematical problem). Teachers have a core role of planning and directing learning. In contrast, constructivist pedagogy, developed by Piaget (1929), views learning an active process engaging the learner with real world applications in which students construct meaning based on comparisons and linkages with prior knowledge. Knowledge is presented holistically as broad concepts are delineated into various attributes or elements. The learning environment promotes student questioning, inquiry, and problem-solving.

Gales and Yan (2001) evaluated data from the Third International Mathematics and Science Study (TIMMS) to determine the differences in student achievement in mathematics based on the pedagogical approaches of teachers. The study consisted of 527 teachers and their 10,970 students. Teachers' pedagogical practices were categorized as either behaviorist or constructivist. The researchers used hierarchal linear regression to determine statistical differences. Results indicated strong negative relationships between teachers' behaviorist approaches to mathematics and student achievement when teachers required students to work independently and promoted expectations of only one correct answer or method. In contrast, teachers' constructivist approach revealed a positive relationship between methods and student achievement when students were given opportunities for learning mathematics in collaborative environments, when problems were posed where there was no immediate correct answer, and content related to real world applications. Outcomes suggest that the pedagogical paradigm and instructional practices teachers use for teaching mathematics can greatly influence student achievement (Gales & Yan, 2001).

Professional Development

Many novice teachers enter the classroom unprepared to deal with the realities, challenges, and difficulties of teaching (Public Education Network, 2004). New teachers learn to navigate the complexity of this profession with the support of professional development provided by their schools and districts. These efforts are geared at improving teacher quality through professional development. Initial teacher support is proven to be one of the most effective investments of districts in promoting teacher retention efforts (Henke, Chen, Geis, & Knepper, 2000).

The role of districts in promoting teacher quality is not limited to novice teachers, but is just as important for experienced teachers. Continued professional growth of experienced teachers through quality, comprehensive professional development helps teachers strengthen content knowledge and pedagogical practices to better meet students' cognitive needs. NCLB legislation also recognizes the value of continual professional development in improving teacher quality and mandates that states have yearly increases in the percentage of teachers receiving high-quality professional development. NCLB defines high-quality as "sustained, intensive, and classroom-focused…" (NCLB, 2001, p. 7).

Although improved teacher quality translates to greater student achievement (Darling-Hammond & Ball, 1997) and that professional development is federally mandated (NCLB, 2001), many districts expend as much as six percent of their operating budget on professional development programs (Public Education Network, 2004). This financial investment does not necessarily equate to efficient use of funds and dollar for dollar student achievement gains cannot be calculated. Many teachers resent the time spent in seminars or training sessions and do not understand the value or utility of these learning experiences. Often these feelings are justified as professional development tends to be isolated training, with limited or no follow-up support, despite federal guidelines for high-quality professional development. Even the evaluations of professional development opportunities fail to determine the effectiveness of their interventions as these assessments focus on participant like and do not follow teachers into the classroom to evaluate pedagogical changes or impacts on student learning. Therefore, limited research exists that evaluates the impact of professional development in terms of changing teachers' pedagogical practices and affects on student achievement (Public Education Network, 2004).

Long-term professional development has been documented as having positive effects on teacher quality. Consequently, well designed, sustained professional development becomes and integral part of determining teacher quality when it targets explicit teacher needs. Despite the recognized benefits of professional development, many states, districts, and school systems are cutting professional development opportunities due to budget crunches (The Center for the Future of Teaching and Learning, 2004).

There are inherent problems in the teaching profession that in contrast to business education does not offer incentives for continued knowledge and skill development. Most teaching raises are calculated on years of experience rather than professional growth or student achievement. There are however, some states that recognize external continuing education as professional development and offer incentives for teachers through pay increases or tuition reimbursements for a master's degree or national board certification. The former option is problematic. These incentives are not tied to the quality of the institution that awarded the degree, the program major, or the teacher's overall academic achievement within the program of study. Thus, any master's degree will do and a diploma now entitles teachers to financial compensation without any evaluation of improvements in teacher knowledge or skills and whether these changes impact student achievement. The latter opportunity for professional development that is financially supported is national board certification. Teachers consider this process extremely rigorous and one that requires extensive introspection and deep reflection; thus, teachers indicate that the national board certification process changes the way they teach, how they think about content, and their understanding of students and learning styles.

Methodology

In this study we examined data from just one large county in Eastern North Carolina. We looked at the relationship between the SEC survey results of 46 elementary school lead teachers and their students end-of-grade (EOG) scaled scores. In all, we examined the EOG scores for 933 students. The average class size was 20.2 students with a minimum of 4 and a maximum of 28. For each lead teacher the average math end-of-grade (EOG) test scaled scores were computed for their students. The classroom math's EOG averages ranged from 245 to 271.6 with an average of 257.5 and a standard deviation of 5.6. These EOG averages were then linked with each teacher and served as the dependent variable in our analyses.

The research questions examined the relationship between teachers' characteristics and their class EOG performance. The goal was to identify which teacher characteristics resulted in significant EOG mean differences. When valid, SEC item responses for some teacher profile components were summed and teachers were subsequently categorized as being low, medium or high on the sum score. EOG mean differences among the three groups were tested for significant differences using analysis of variance (ANOVA). For other research questions, individual item responses resulted in natural categories and then these categories were tested for significant EOG mean differences.

Results & Interpretations

The study content focus was mathematics instruction and student achievement in mathematics. Participants in this study include forty-six elementary teachers and 933 students. Of the participating teachers, forty-two (91.3 %) were female and four (8.7%) were male. There were thirteen (28.2%) African-American teachers and thirty-one (71.8%) White teachers. Table 1 shows the breakdown of teachers by years taught. Only two teachers had been teaching less than a year, and 11 teachers (23.4%) have taught for more than 15 years.

Table 1. Frequency of teachers broken down by number of years taught

	Frequency	Percent	Cumulative Percent
Less than 1 year	2	4.3	4.3
1-2 yrs	4	8.5	13.0
3-5 yrs	4	8.5	21.7
6-8 yrs	9	19.1	41.3
9-11 yrs	8	17.0	58.7
12-15 yrs	8	17.0	76.1
>15 yrs	11	23.4	100.0
Total	46		

Interestingly there was a high degree of mobility of teachers. Over a third of the teachers have taught from one to two years in their current school. Only three teachers have taught in the same school for more than 15 years. This information is presented in Table 2.

Table 2. Number of years taught at present school

	Frequency	Percent	Cumulative Percent
<1 yr	4	8.5	8.7
1-2 yrs	14	29.8	39.1
3-5 yrs	8	17.0	56.5
6-8 yrs	11	23.4	80.4
9-11 yrs	6	12.8	93.5
12-15 yrs	3	6.4	100.0
Total	46		

Data were evaluated to determine if there teacher demographic were significant factors in determining teacher effect profiles and the teacher impact on student achievement. There were no significant differences based on gender and ethnicity. Additionally, teacher perceptions of student cognitive abilities did not adversely affect student achievement. Analyses were performed to determine the significance of each of the variables within the four teacher profiles in impacting student achievement in mathematics.

Teacher Training Profile

The first profile, Teacher Training, included five variables of degree level, licensure grade level, licensure level, content and pedagogical preparation, and content knowledge. There were no significant differences in student achievement for all variables except licensure type. Licensure type is defined as elementary education, middle school education, mathematics education, mathematics, math education and math, or other content areas. Forty-three of the elementary lead teachers were certified to teach in the state. Of these the majority were certified to teach at the elementary level (EGC). Two teachers were certified at the middle grades (MGC), four were teaching in the elementary school but were certified at the high school level but not in math (SCNM) and four were teaching at the elementary level but certified to teach high school math (SC). The average math EOG scores by level of certification is presented in Table 3. ANOVA results are shown in Table 4. Results indicated a moderate effect of .206.

Table 3. Mean math EOG scaled score by teacher state certification level

Dependent Variable: mss

stcert	Mean	Std. Deviation	N
EGC	256.1888	5.19106	33
MGC	261.5200	.56569	2
SCNM	264.3400	5.99463	4
SC	256.2775	5.79308	4
Total	257.2033	5.66842	43

Table 4. ANOVA comparing mean EOG math scores by State Certification Type

Dependent Variable: mss

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power(a)
stcert	278.391	3	92.797	3.379	.028	.206	.720
Error	1071.113	39	27.464				
Total	1349.504	42					

a Computed using alpha = .05

The significance reported may be attributed to the difference in content preparation between the elementary and secondary licensure. The latter certification requires a greater intensity in content training or often a content degree. The additional content preparation, which results in improved content knowledge, can positively impact student achievement, although this impact is limited by the type of content coursework. These findings are consistent with previous research which links teachers' content knowledge to student learning (Goldhaber & Anthony, 2003; Goldhaber & Brewer, 1999; Lasley, Bainbridge, & Berry, 2002).

When evaluating teacher content knowledge, there were no significant differences in three areas: beginning content knowledge, advanced content knowledge, and math education content training. The math content that elementary teachers are required to teach focuses on basic mathematics principles, calculations, and applications; thus, higher levels of mathematics content training are not applicable in this context. As a result, advanced content training is not as important as beginning content training and content specific pedagogical training. These findings are in contrast to research that criticizes the discrepancies of elementary education programs in content preparation in contrast to content degree programs (Ball, 1990; Rech, Hartzell, & Stephens, 1993; Tirosh & Graeber, 1989). The results of this study suggest further research is needed to explore the necessity and impact of higher level content training and whether this higher level knowledge improves elementary students' achievement in mathematics.

Degree level was not significant in this study. All teachers were licensed through traditional programs and licensure was part of their degree. Teachers had either completed an undergraduate degree or an undergraduate degree and a master's degree. The lack of influence of the master's degree in changing the teacher effect raises questions as to the value of the additional degree. These results are consistent with prior studies suggesting that a master's degree is not significant in affecting student achievement in mathematics (Heafner, Ackerman, Barts, 2005), because of the variability in the quality of programs and lack of accountability for individual teacher performance within these programs (Public Education Network, 2004).

Teaching Experience Profile

The second teacher profile focuses on the role of teaching experience and how this affects student learning. This profile contains only one variable as teaching experience is one of the most important factors in determining student success. As expected, teaching experience was significant in impacting student achievement in mathematics as noted below in Table 5. A positive relationship exists between teaching experience and student learning. Years of experience provide opportunities for teachers to improve their knowledge of the content, hone pedagogical approaches, and refine their understanding of student cognition and attributes. Consequently, experience greatly improves performance. These findings are consistent with prior studies (Cooney, 2003; Felter, 2001; Goldhaber & Anthony, 2003; Lasley, Bainbridge, & Berry, 2002).

Table 5. ANOVA comparing mean EOG math scores by years of teaching

Dependent Variable: mss

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power(a)
tepyte	432.237	6	72.040	2.827	.023	.320	.822
Error	917.266	36	25.480				
Corrected Total	1349.504	42					

a Computed using alpha = .05

Pedagogical Practices Profile

The next profile is Teacher Pedagogical Practices Profile. This profile is the most complex of the four teacher profiles. Teachers' pedagogical practices are a composite of many variables. First, how teachers teach is shaped by their pedagogical paradigm. These beliefs fall on a continuum between traditional and constructivist pedagogy. The impact of these approaches on student achievement in mathematics varies. Questions were divided into two categories of teaching methods and assessment methods. Teacher responses were then categorized as three groups (low, medium, high) based on teacher alignment with each pedagogical paradigm. Results indicate that there were no significant differences in student achievement when either traditional or constructivist pedagogical approaches were used for teaching mathematics. This suggests that there is not one best method for teaching mathematics, but instruction should be a composite of both traditional and constructivist strategies. These findings were in alignment with the results of the study conducted by Gales & Yan (2001).

Additional analyses revealed differences in the ordering within groups. Order was maintained for the traditional paradigm. The impact on student achievement was increased as teachers more closely aligned with traditional pedagogy. Traditional methods for teaching mathematics are the most common methodology applied and are, in many cases, the strategies that teachers were exposed to in their own learning experiences. Teachers' comfort and familiarity with methods shapes their effectiveness in applying these strategies. The more efficient use of methods positively impacts student learning.

In contrast, order was not consistent for the three groups within the constructivist paradigm. The highest group did have the greatest affect on student learning of mathematics; although the middle group had the lowest student achievement scaled score. Teachers who are not greatly aligned with constructivist pedagogy, the low group, do not frequently employ these methods for teaching mathematics; therefore, there is little impact on student achievement. At the opposite end are teachers who greatly align with constructivist philosophy and effectively utilize this approach for improving student learning of mathematics. The middle group is somewhat aligned with constructivist beliefs and applies constructivist principles as part of their teaching. These teachers do not employ constructivist methods as often or consistently as the high constructivist group. This raises questions as to the preparation of these teachers in using constructivist methods. The use or application of a method is not an indication of appropriate or effective implementation. Constructivist methods for teaching mathematics are fairly new to the profession in comparison with traditional methods. More experienced teachers may not have had the pedagogical training in these strategies during their degree preparation and probably were not exposed to these methods in their own schooling experiences. In many cases, constructivist pedagogy was learned through professional development. The lack of extensive familiarity and experience with these methods may have attributed to the difference among constructivist groupings. These results suggest that more rich professional development and follow-up support for using constructivist methods are needed.

The second category within both traditional and constructivist groups was assessment. Traditional assessment methods were defined as objective test questions, performing a mathematical procedure, and an extended response test item in which students were asked to explain or justify an answer. Constructivist assessment strategies include performance-based tasks, such as hands-on activities, presentations, demonstrations, projects, and portfolios, and systematic observations of student learning. There were no significant differences in either assessment approach. For both paradigms, order was maintained. Data suggest that a mix of traditional and constructivist assessment strategies is most appropriate for scaffolding student learning of mathematics.

The third category of the Pedagogical Practice Profile is teacher motives and purpose for teaching. Questions evaluated the external influences shaping instructional practices. These are the factors that shape teachers decisions in what to teach and how to teach. There were a total of ten questions for the SEC that were used to evaluate these influences. Questions were categorized into five major influences: curriculum standards, standardized tests, textbooks, individualized curriculum, and pedagogical training. Teachers responded as to the level of influence of each of these factors. There were significant differences in impacting student achievement in mathematics for three of these categories: curriculum standards, standardized tests, and individualized curriculum. The textbook and pedagogical training were not important variables in shaping teachers' instructional decision-making. The driving force that shapes how and what teachers teach is defined by the standards that students are required to learn and the accountability for learning. This is reflective of the standards-based movement and the current educational initiatives that promote curriculum as the guideline for teaching and student learning. External pressures to teach mandated curriculum, such as NCLB or state accountability systems, greatly influence instructional decision-making. This conscious decision to focus on mandated curriculum appears to have a positive impact on student learning as students are more prepared in the content knowledge and skills for which they are evaluated. Curriculum and assessment thus align.

Responses to SEC questions 72, 73, 77, and 81 were summed. These totals represented the degree to which lead teachers said that state standards and guidelines influenced their teaching. Teachers were grouped into three categories (low, medium, and high) by degree of influence, of these features. Average math EOG scores by category are displayed in Table 6 and corresponding ANOVA results are given in Table 7.

Table 6. Mean math EOG scores by level of influence of state standards.

curr3	Mean	Std. Deviation	N
Low	254.6829	5.57047	7
Med	255.1600	5.44924	16
High	259.9191	4.78348	23
Total	257.4670	5.60298	46

Table 7. ANOVA results comparing mean math scores for different levels of influence of state's curriculum framework and standards

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power(a)
standard	277.714	2	138.857	5.261	.009	.197	.807
Error	1134.991	43	26.395				
Total	1412.705	45					

a Computed using alpha = .05

Influence of state and district test results were surveyed in SEC questions 75 and 76. Responses to these items by lead teachers were summed. Using their total scores, teachers were then grouped into three categories according to how much the state test results influenced their teaching. Mean EOG scores were then computed for the three levels, low, medium and high and compared using ANOVA. Results are displayed in Table 8 and corresponding ANOVA results in Table 9.

Table 8. Descriptive Statistics for math EOG results by influence of state and district tests.

tests3	Mean	Std. Deviation	N
Low	252.9800	4.71369	13
Med	259.5253	3.99345	17
High	258.9256	5.90549	16

Table 9. ANOVA results comparing mean math EOG scores by level of influence of state/district test results.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power(a)
tests3	367.794	2	183.897	7.568	.002	.260	.930
Error	1044.910	43	24.300				
Total	1412.705	45					

a Computed using alpha = .05

The influence of individualized needs of students was explored in SEC questions 79 and 80. Responses to these two items were summed. Based upon their total scores lead teachers were placed into three categories low, medium, and high. Mean EOG math scores were computed for each level and are listed in Table 10 and corresponding analyses in Table 11. Results showed a significant effect with a small effect size and adequate power.

Table 10. Mean math EOG scores for different levels of influence according to students' individualized needs.

ind3	Mean	Std. Deviation	N
Low	254.7265	5.24124	17
Med	258.6088	5.29032	26
High	263.1000	2.89130	3

Table 11. ANOVA results comparing mean EOG math scores by level of influence of individual student differences.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power(a)
ind3	256.770	2	128.385	4.776	.013	.182	.766
Error	1155.935	43	26.882				
Total	1412.705	45					

a Computed using alpha = .05

The fourth category of the Pedagogical Paradigm includes the organization of instruction and resources teachers use for teaching mathematics. The first subcategory was comprised of task structure and the cognitive level of the task. Task structure was defined as whether these tasks are individual or collaborative assignments. Specifically, the types of students' activities were put into a continuum: from only individual instruction tasks (1) to collaborative tasks, (5). Lead teachers who put down little time spent for both categories were eliminated. Those who indicated they used both pedagogical procedures both equally were given a 3. The mean EOG math score was computed for each level and tested for significance. These are reported in Table 12. The ANOVA F was not significant.

Table 12. Mean math EOG scores by level of individualized (1) versus collaborative (5) approaches to instruction.

category	Mean	Std. Deviation	N
1.00	264.3000	.	1
2.00	260.9033	6.64990	9
3.00	259.1567	2.17849	6
4.00	256.0956	5.12592	9
5.00	256.6583	5.04477	12

The second subcategory evaluated the cognitive level of the task. Tasks were divided into three cognitive levels. Level one tasks require students to perform simple mathematical tasks using worksheets or textbook resources. Level two tasks provide opportunities for students to develop higher-order thinking skills through tasks that require students to explain reasoning and thinking, apply concepts to "real-world" problems, make predictions, and formulate hypotheses. Level three tasks are complex tasks that challenge students to move to even higher levels of understanding. Students are expected to analyze data, make inferences, draw conclusions, and conduct proofs or demonstrations of their mathematical reasoning. Data analyses revealed no significant differences in task structure or cognitive level of the task. Students benefit from a variety of individual and collaborative learning experiences. For the cognitive level of the task, it is important to note that order was maintained. Higher level cognitive tasks did have the greatest impact on student achievement. The more challenging a task is, the greater student achievement (Blumenfeld, Mergendoller, & Swarthout, 1987; Eccles et al., 1983).

Technology is an important resource for teaching mathematics and in supporting student understanding of mathematics; therefore, questions were posed to evaluate teacher use of calculators, computers, and other educational technology. Results indicated significant mean math EOG differences resulted from lead teachers' technology use. Lead teachers were divided into low, medium, and high use categories and then for each category mean EOG score was computed and then tested for significant differences. These results are displayed in Tables 13 and 14. A moderate effect size, .214, leads to a significant F-value. The more frequent and extensive use of technology the more positive the impact on student achievement. Consequently, professional development opportunities need to focus on building teachers' knowledge of and skills in using technology for teaching mathematics. The benefits of technology in scaffolding student learning and the need for support teachers in the development of appropriate pedagogical integration of technology as cited in these results are supportive of current research (Brabec, Fisher, & Pitler, 2004; Learning Point Associates, 2006).

Table 13. Mean math EOG scores by level of technology employed in the classroom activities.

Category	Mean	Std. Deviation	N
Low	255.3822	4.54978	18
Med	255.1460	6.01630	10
High	260.7600	5.21030	15
Total	257.2033	5.66842	43

Table 14. ANOVA comparing mean EOG math scores by level of technology use

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power(a)
imtu3	291.770	2	145.885	5.517	.008	.216	.824
Error	1057.733	40	26.443				
Total	1349.504	42					

a Computed using alpha = .05

The final category of the Pedagogical Paradigm is teachers' use of homework. Use is explained by the accountability of homework (Tables 15 and 16) which relates to how teachers assess student homework and the value associated with homework in computing final grades; the cognitive level of homework tasks (Tables 17 and 18) that follows the previously defined three levels; and the frequency homework is assigned (Tables 19 and 20). All three factors resulted in significant mean EOG differences. Consequently, data indicate that homework is an important determinate of student achievement as previously noted (Stronge, 2002; Stronge & Hindman 2006; Stronge, Tucker, & Hindman, 2004).

Accountability significantly impacts students' achievement. If students are held accountable for the accuracy of their work and they see value in their efforts, then assessment becomes a supportive learning process that positively impacts student learning.

Table 15. Mean math EOG scores by level of accountability of student work included in course grades.

Dependent Variable: mss

hwa	Mean	Std. Deviation	N
.00	251.3244	4.39204	9
1.00	258.2371	6.03188	7
2.00	257.6518	3.94626	17
3.00	260.8614	5.74954	7
4.00	259.6875	3.81985	4
5.00	264.5200	2.14960	2
Total	257.4670	5.60298	46

Table 16. ANOVA results comparing mean EOG math scores by level of accountability of what is included in computing students' grades.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power(a)
Account	544.178	5	108.836	5.012	.001	.385	.968
Error	868.526	40	21.713				
Total	1412.705	45					

a Computed using alpha = .05

Data suggests that the cognitive level of the task is important. Level one tasks did not significantly affect student achievement. Basic cognitive tasks build foundational knowledge, but higher order tasks are needed to improve student achievement as indicated by results for level two tasks. Level two tasks (SEC questions 16 and 17) produced significant mean EOG score differences. Results for level three were not significant and this can be explained to the teacher use of level three tasks. The n was too small for significant results to be achieved. The question remains as to the potential impact that level three tasks could have on student learning of mathematics. Again this is an area where professional development could target teacher effectiveness.

Table 17. Mean EOG scores by level of usage of Level 2 tasks.

Level 2 Use	Mean	Std. Deviation	N
Low	255.4629	6.12218	14
Med	256.1976	4.89339	17
High	260.7760	4.58616	15
Total	257.4670	5.60298	46

Table 18. ANOVA results comparing mean EOG math scores by frequency of Level 2 homework activities.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power(a)
Level 2	247.866	2	123.933	4.575	.016	.175	.747
Error	1164.839	43	27.089				
Total	1412.705	45					

a Computed using alpha = .05

Finally, there is a positive relationship between frequency of assigned homework and student achievement in mathematics. Students need frequent opportunities to practice and apply concepts learned in class. In the corresponding analysis there was a relatively moderate effect size.

Table 19 .Mean math EOG scores by level of frequency of assigned homework (1=infrequent, 6=frequently)

Freq	Mean	Std. Deviation	N
1	247.5000	2.55147	3
2	261.5000	.	1
3	255.0820	1.28311	5
4	257.1195	5.62680	20
5	260.9722	5.26931	9
6	259.1163	3.62400	8

Table 20.ANOVA results comparing mean EOG math scores by frequency of homework assignments

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power(a)
Freq of Hmwrk	477.484	5	95.497	4.084	.004	.338	.924
Error	935.221	40	23.381				
Total	1412.705	45					

a Computed using alpha = .05

Professional Development Profile

The fourth teacher effect profile is Professional Development and evaluates the content, purpose for participation, and frequency/amount of professional develop of teachers. Teacher effectiveness can be greatly impacted by their growth through training in content and pedagogy. Professional Development profiles were created based upon frequency of professional development activities. SEC questions 102-105,107 and 111 were summed and teachers were divided into three categories of frequency: low, medium, and high based upon their total scores. Mean EOG scores were compared across the levels. Results are reported below in Table 21 and Table 22. There were no significant differences in student achievement based upon the content or teacher rationale for participating in professional development. What matters more is the frequency and amount of professional development. Student achievement in mathematics is improved with the increases in teachers' professional development. These results support the national mandates for increased professional development (NCLB, 2001) and the recognized benefits of professional development (Lasley, Siedentop, & Yinger, 2006). The more teachers participate in professional development, the more effective they become in supporting student understanding of mathematics. This finding is very important to this study as one goal of NCPIMS is to improve teachers' instructional practices through professional development. Previous results suggest that the efforts can be targeted toward specific deficiencies and potentially have a greater impact on student achievement (Craig & Cairo, 2005).

Table 21. Mean math EOG score by level of frequency of professional development.

pdpt3	Mean	Std. Deviation	N
Low	260.4415	5.97034	13
Med	254.2319	5.23605	16
High	258.1013	4.29065	16

Table 22. ANOVA results comparing mean EOG math scores for different frequency levels of professional development activities

Dependent Variable: mss

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power(a)
pdpt3	288.723	2	144.361	5.437	.008	.206	.820
Error	1115.128	42	26.551				
Total	1403.851	44					

a Computed using alpha = .05

Teacher Effect Model Profiles

Additional analyses were performed to evaluate the overall impact of teacher characteristics. A regression was run to determine which components of the profile would be the best predictors of the EOG math scores. A stepwise multiple regression was conducted. In the first step Homework accountability (HWA) (degree of accountability into the student's grade) was entered. The second model included homework accountability and years taught (YRST). The third and final model included HWA, YRST and influence of state standards and curriculum guide (ISSCG). In all the three variables accounted for 54% of the variance of the math EOG scores. All predictors were highly significant. Thus, the three most important teacher characteristics for positively influencing student achievement are: homework accountability, years taught, and the influence of curriculum standards for shaping instructional practices.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.551(a)	.303	.287	4.76883
2	.680(b)	.463	.437	4.23813
3	.757(c)	.574	.542	3.82116

a Predictors: (Constant), hwa
b Predictors: (Constant), hwa, yrst
c Predictors: (Constant), hwa, yrst, isscg

Educational Importance

This Teacher Effect Model provides a framework for future analyses of the impact of intervention strategies for evaluating and improving professional development. It serves a dual purpose of evaluating the effect of variables that define teacher quality in terms of student achievement which address a recognized gap in the literature (Public Education Network, 2004) and directing professional development planning through the identification of teacher pedagogical needs as determined by student learning outcome data. This latter purpose addresses the national mandate of NCLB of providing high-quality professional development.

References

Alternative choices. (2005, March). *Education Week*, 24(26), 43-46.

Ball, D.L. (1990). Prospective elementary and secondary teachers' understanding of division. *Journal of Research in Mathematics Education*, 21, 132-144.

Blank, Rolf K. (2002). Using surveys of enacted curriculum to advance evaluation of instruction in relation to standards. *Peabody Journal of Education*, 77(4), 86-121.

Brabec, K., Fisher, K., & Pilter, H. (2004). Building better instruction: How technology supports nine research-driven instructional strategies. *Learning and Leading with Technology*, 31(5), 6-11.

Capraro, R.M., Capraro, M.M., Parker, D., Kulm, G., Raulerson, T. (2002). Conventional wisdom is wrong: Anyone cannot teach and teachers are not born. ERIC Clearinghouse on Teaching and Teacher Education. ERIC Digest: ED463259.

Collias, K., Pajak, E., & Rigden, D. (2000). One cannot teach what one does not know: Training teachers in the United States who know their subjects and know how to teach their subjects. Retrieved April 4, 2005 from http://curie.umd.umich.edu/TeacherPrep/120.pdf.

Cooney, S. (2003). A highly qualified teacher in every middle grades classroom: What states, districts and schools can do. Southern Regional Education Board, Atlanta, GA. Available online: http://www.sreb.org/programs/hstw/publications/pubs.

Coupal, L. V. (2004). Constructivist learning theory and human capital theory: Shifting political and educational frameworks for teachers' ICT professional development. British Journal of Educational Technology, 35(5), 587-596.

Craig, J. & Cario III, L. (2005). *Assessing the relationships between questioning and understanding to improve learning and thinking (QUILT) and student achievement in mathematics: A pilot study.* Charleston, WV: Appalachia Educational Laboratory at Edvantia, Inc.

Darling-Hammond, L. & Ball, D. L. (1997). *Teaching for high standards: What policymakers need to know and be able to do.* Washington, DC: National Commission on Teaching and America's Future.

Darling-Hammond, L., Chung, R., & Frelow, F. (2002, September/October). Variation in teacher preparation: How well do different pathways prepare teachers to teach? *Journal of Teacher Education*, 53(4), 286-302.

Darling-Hammond, L. (2000). Teacher quality and student achievement: A review of state policy evidence. Education Policy Analysis Archives, 9, Retrieved March 30, 2005 from http://epaa.asu.edu/epaa/v8n1/.

Elementary and Secondary Education Act: No Child Left Behind. (2001). Washington, DC: U.S. Department of Education.

Feistritzer, C. E. (1998, February). *Alternative teacher certification: An overvie*w. Washington, DC: National Center for Education Information. Retrieved July 28, 2003, from The National Center for Education Information Web site: http://www.ncei.com.

Frome, P., Laster, B., & Cooney, S. (2005). Well-qualified teachers and high quality teaching: Are they the same? Southern Regional Education Boar. ERIC Clearinghouse. ERIC Digest: ED-485-264.

Gagne, R. M. (1985). *The conditions of learning*. (4th ed.). New York: Holt, Rinehart, and Winston.

Gales, M. J. & Yan, W. (2001, April). Relationship between constructivist teacher beliefs and instructional practices to students' mathematical achievement: Evidence TIMSS. ERIC Clearinghouse. ERIC Digest: ED-456-133.

Goldhaber, D., & Anthony, E. (2003). Indicators of teacher quality. ERIC Clearinghouse on Urban Education. ERIC Digest: EDO-UD-03-3.

Goldhaber, D. D., & Brewer, D. J. (1999). *Teacher licensing and student achievement.* Better Teachers, Better Schools. Washington, DC: Thomas B. Fordham Foundation, 83-102.

Grayson, D. A. (2003). Using equitable practices to improve educational quality: Implementation examples and results. ERIC Clearinghouse. ERIC Digest: ED-482-352.

Heafner, T., Ackerman, T., & Barts, D. (2005, April). *An examination of the relationship between teacher quality and student EOG performance.* Paper presented at American Educational Research Association Annual Meeting, Montreal, Canada.

Henke, R. R., Chen, X., Geis, S., & Knepper, P. (2000). Progress through the teacher pipline: 1992-1993 college graduate and elementary/secondary school teaching as of 1997. Washington, DC: U.S. Department of Education.

Kanstroom, M., & Finn, C. (Eds.) (1999). Better teachers better schools. Washington, D.C.: Education Leaders Council, Thomas B. Fordham Foundation. Retrieved July 30, 2003, from The Educational Forum of Kappa Delta Pi: http://www.edexcellence.net/better/tchrs/btbs.htm.

Klecker, B. M. (2002). The relationship between teachers' years-of-teaching experience and students' mathematics achievement. ERIC Clearinghouse. ERIC Digest: ED-471-550.

Laczko-Kerr, I., & Berliner, D. C. (2002, September 6). The effectiveness of "Teach for American" and other under-certified teachers on student academic achievement: A case of harmful public policy. *Education Policy Analysis Archives*, 10(37). Retrieved October 9, 2002 from http://epaa.asu.edu/epaa/v10n37/.

Lasley, T. J., Bainbridge, W. L., & Berry, B. (2002, November). Improving teacher quality: Ideological perspectives and policy prescriptions. . Retrieved July 28, 2003, from The Educational Forum of Kappa Delta Pi: http://www.schoolmatch.com/articles/EFNOV02.htm.

Lasley, T. J., Siedentop, D., & Yinger, R. (2006). A systemic approach to enhancing teacher quality: The Ohio model. Journal of Teacher Education, 57(1), 13-21.

Learning Point Associates. (2006). *Critical issue: Using technology to improve student achievement.* North Central Regional Educational Laboratory.

Lloyd, C. Race at the center: Perspectives on improving science and math achievement. ERIC Clearinghouse on Urban Education. ERIC Digest: ED-457-176.

Matthews, J. (2002, July 9). Teacher training: Too much or not enough? Washington Post. Retrieved July 30, 2003 from http://nl.newsbank.com/archives.

Minichello, J.R. (2004). Students of national board certified teachers achieve larger gains on statewide math test in Florida. National Board for Professional Teaching Standards Press Release November 17, 2004.

Monk, D.H. (1994). Subject matter preparation of secondary mathematics and science teachers and student achievement. *Economics of Education Review*, 13(2), 125-145.

Piget, J. (1929). *The child's conception of the world*. (J. & A. Tomlinson, Trans.) New York: Harcourt, Brace & World.

Poliakoff, A. R, ed. (2002). Teacher preparation: Assessing teacher quality, administrative support, standards-based teacher preparation. Washington, DC: Council for Basic Education.

Quinn, Robert J. (1997). Effects of mathematics methods courses on the mathematical attitudes and content knowledge of preservice teachers. *Journal of Educational Research*, 91(2).

Rech, J., Hartzell, j, & Stephens, L. (1993). Comparisons of mathematical competencies and attitudes of elementary education majors with established norms of general college population. *School Science and Mathematics*, 93(3), 141-145.

Sanders, W.L., & Rivers, J.C. (1996). Cumulative and residual effects of teachers of future student academic achievement. Retrieved April 4, 2005 from http://www.mccsc.edu/~curriculum/cumulative%20and%20residual%20effects%20of%20teachers.pdf.

Sokal, L., Smith, D. G., & Mowat, H. (2003). Alternative certification teachers' attitudes toward classroom management. *High School Journal*, 86(3), 8-17.

Stronge, J. H. (2002). *Qualities of effective teachers.* Alexandria, VA: Association for Supervision and Curriculum Development.

Stronge, J. H. & Hindman, J. L. (2006). *The teacher quality index: A protocol for teacher selection.* Alexandria, VA: Association for Supervision and Curriculum Development.

Stronge, J. H., Tucker, P. & Hindman, J. L. (2006). *Handbook for qualities of effective teachers.* Alexandria, VA: Association for Supervision and Curriculum Development.

Sunderman, G. L. & Kim, J. (2005). *Teacher quality: Equalizing educational opportunities and outcomes.* Cambridge, MA: The Civil Rights Project.

Suh, T., & Fore, R. (2002). The national council on teacher quality: Expanding the teacher quality discussion. ERIC Clearinghouse on Teaching and Teacher Education. ERIC Digest: ED477730.

The Center for the Future of Teaching and Learning. (2004). Rising expectations vs. declining resources.

The National Center for Education Information (2003). *Alternative teacher certification: A state-by-state analysis 2003.* Retrieved July 28, 2003, from The National Center for Education Information Web site: http://www.ncei.com.

Tirosh, D., & Graeber, A.O. (1989). Preservice elementary teachers' explicit beliefs about multiplication and division. *Educational Studies in Mathematics*, 20, 79-96.

Vandevoort, L.G., Amrein-Beardsley, A., & Berliner, D. C. (2004). National board certified teachers and their students' achievement. *Educational Policy Analysis Archives, EPAA* 12(46), 1-177.

Whiting, M. E., & Klotz, J. (2000). Alternative certification: It's alive, it's alive…but it may not be well. *Contemporary Education*, 7(3), 39-42.

Zuelke, D. C. (2001). Attitude, cost, and school effects on sixth-grade achievement.