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Mathematics Reform and Teacher Quality in Elementary Grades: Assessments, Teacher Licensure, and Certification[1]

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Abstract: We analyzed the gap in mathematics standards, assessments and accountability, and teacher licensure and certification requirements in mathematics for elementary grades. We found states delineated mathematics academic standards in specific content areas. Licensure and certification requirements were weak indicators since they lacked the specificity of conceptual and procedural knowledge that could strengthen mathematics content knowledge and inform instructional practices. The most recent changes in licensure and certification requirements intended to affect teacher quality are not reaching a large proportion of elementary teachers; thus, their overall impact on teacher quality is likely to be limited. We discuss policy strategies for licensure and certification requirements likely to have a

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broader reach in addressing teacher quality at the elementary grades.
Keywords: elementary school mathematics; teaching; teacher improvement.

Reforma matemática y calidad docente en la escuela primaria: Evaluaciones, licencias y certificación docente

Resumen: Se analizaron las diferencias en estándares, evaluaciones, procesos de rendición de cuentas, y requisitos de certificación docente en el área de matemáticas para la escuela primaria. Encontramos que los Estados determinaron los niveles académicos en matemáticas en áreas de contenido específicos. Las licencias y los requisitos de certificación son indicadores débiles porque carecen de especificidad sobre conocimientos conceptuales y de procedimiento que podrían reforzar los conocimientos acerca de los contenidos de matemáticas e ayudar a mejorar a las prácticas de enseñanza. Los cambios más recientes en los modelos de licenciamiento y los requisitos de certificación que intentan mejorar la calidad de la formación de los docentes en el área de matemáticas no llegan a la mayoría de los maestros de primaria, por lo que su impacto global es bastante limitado. Discutimos las estrategias de política para obtener la licencia y los requisitos de certificación que podrían tener un mayor alcance para mejorar la calidad de los docentes en la escuela primaria.
Palabras-clave: enseñanza de las matemáticas en la escuela primaria; enseñanza; formación docente.

Reforma matemática e qualidade de professores no Ensino Fundamental: Avaliações, licenciamento e certificação de professores

Resumo: Analisamos a brecha nos padrões, nas avaliações e processos de prestação de contas, bem como o licenciamento e a certificação solicitados para o ensino de matemática do Ensino Fundamental. Encontramos estados determinaram padrões acadêmicos de matemática em áreas específicas de conteúdo. As solicitações de licenciamento e certificação foram indicadores fracos, uma vez que falta-lhes a especificidade do conhecimento conceitual e prático que poderiam reforçar o conhecimento do conteúdo de matemática e aperfeiçoar as práticas educativas. As recentes mudanças nas solicitações de licenciamento e certificação que buscaram afetar a qualidade docente não estão atingindo a maioria dos professores de Ensino Fundamental; desse modo, o impacto geral sobre a qualidade docente torna-se limitado. Discutimos estratégias políticas de licenciamento e os requisitos de certificação que possam ter um alcance mais amplo no endereçamento da qualidade docente no Ensino Fundamental.
Palavras-chave: matemática do ensino fundamental; ensino; aperfeiçoamento de professores.

Introduction

In an evolving policy environment of increasing state involvement in setting standards and accountability, few studies have examined how well mathematics academic standards, assessments, and accountability policies cohere with policy changes in licensure and certification requirements for elementary school teachers. There is an emerging gap between the academic standards students are expected to meet, the assessments to gauge what students know, and states' varying capacities to improve teacher effectiveness at the elementary grades given that when considered together as policy instruments, teacher preparation, licensure and certification requirements, and in-service standards for professional development are weakly aligned with content and academic standards expected of elementary school students. Moreover, these policy instruments may be an imperfect proxy for mathematical knowledge and insufficient to assure that elementary school teachers possess the content knowledge to teach to stronger academic standards. If not addressed such a gap may be difficult to overcome and weaken student learning.

In the current study our goal was to examine the gaps among standards, assessments, accountability policy, and teacher quality policy at the elementary grades. We compiled a longitudinal database on elementary school teacher licensure and certification requirements in mathematics, student academic standards, assessments, and accountability policies for all 50 states and the District of Columbia. We also compiled information on requirements for professional development, mentoring, and peer support programs for these teachers. Our analysis covers elementary school teachers in grades one through five.

We ask two questions. First, what are the mathematics standards, assessments and accountability policies, and teacher licensure and certification requirements in mathematics at the elementary school level? Second, what is the relationship between assessment and accountability practices and the teacher licensure and certification requirements in mathematics at the elementary school level? We examined each question at both national and state levels. We illuminate differences between states by examining in greater details the mathematics content standards for California, Florida, and New York, states chosen to reflect diversity and experience with standards and assessments. Collectively these three states account for 25% of the nation's elementary public school enrollment in grades one to five (Sable & Hill, 2006).

We focus on teacher-quality for elementary school teachers because students' mathematical experiences and knowledge during the elementary grades constitute an important building block for later academic success in mathematics (National Mathematics Advisory Panel [NMAP], 2008). The NMAP emphasized the important role of elementary mathematics instruction in preparation for algebra and building the foundation for long-term mathematics learning. A key component in preparing students to succeed in mathematics in high school and beyond is to have effective elementary school teachers (NMAP, 2008). Policies to improve teacher quality focus on licensure and certification requirements, including requirements for professional development, with the intended results that through meeting these requirements teachers maintain and acquire the content knowledge related to the academic standards expected of students. However, our analysis showed that licensure and certification requirements in their current formulations do not address the core of what affects teacher quality and mathematics content knowledge. Our analysis also demonstrates that professional development requirements are often insufficient and disconnected sets of activities that may not align with the subjects elementary teachers must teach.

We begin by reviewing the relevant literature and define teacher quality for this study. We next describe our method, including how we compiled our 50-state policy database, and our analytic procedure. After presenting findings, we discuss the implications for strengthening policies to improve teacher quality in the elementary grades.

Literature

Prior studies have examined variations in standards, assessments and accountability. Emergent evidence shows a gap between assessments and accountability, on the one hand, and licensure and certification requirements, on the other.

Variations in Standards, Assessments, and Accountability

Two prior studies employed a quantitative approach to examine the adoption of standards-based reform in all academic subjects and for all grade levels (Lee, 1997; Swanson & Stevenson, 2002). Neither study, however, differentiated the analysis by subject matter or specific grade levels, nor did the researchers address the progress states made in the availability of resources to improve teacher quality across specific grade levels.

In the first study, Lee (1997) gathered data from the Education Testing Service (ETS) and from the Council of Chief State School Officers (CCSSO) to compare patterns in 43 policies across all states covering all grades and all academic subjects between 1984 and 1991. Based on a policy score derived from a Rasch measurement model, Lee concluded that Maryland, Oregon, and Kentucky were the most active states because they adopted more complex and innovative policies during that period. In the second study, Swanson and Stevenson (2002) examined 22 policies encompassing mathematics, science, history, and language arts, basing their analyses on data collected from CCSSO surveys of all states conducted in 1996 and 1997. The policies examined covered student academic standards, assessments, and accountability as well as teacher licensure standards and certification requirements. Similar to the approach taken by Lee (1997), Swanson and Stevenson (2002) created a composite policy score using a Rasch measurement model to quantify varying levels of policy adoption in each state and to assess policy coherence across states. Their ranking of the states using the Rasch policy score were similar to Lee's rankings. Specifically, Alabama, Maryland, Kentucky, and North Carolina were ranked as most active in adopting standards-based reforms during the mid-1990s (Swanson & Stevenson, 2002). However, neither study examined teacher entrance and teacher quality policy separately, nor did the researchers show how changes in assessment and accountability policy were aligned with teacher quality policy during this period.

Variations in Teacher Qualifications Requirements

Using data from the School and Staffing Survey, Blank (2003) examined the proportion of mathematics teachers in grades seven to twelve who met two benchmarks: having a teaching certificate in mathematics and having a major in mathematics or mathematics education. His results showed that the proportion of teachers with both certification and a major in mathematics was lower than the proportion of teachers who had attained a major in mathematics only, suggesting that mathematics teachers tend not to attain state certification in mathematics. In particular, the large states of California, Florida, New York, North Carolina, and Michigan suffered severe shortages of mathematics teachers with mathematics certification (Blank, 2003). Overall, Blank concluded that in grades seven to twelve few states have been able to keep pace with mandates for qualified mathematics teachers mandated by the No Child Left Behind (NCLB) Act.

Inequities in teacher quality have been documented across schools and student populations. Studies showed a systematic sorting of teachers with poor qualifications to schools with higher concentrations of poor, Black, Latino, and low-performing students. For example, such sorting was documented in New York City where minority and poor students were disproportionately less likely to have certified teachers compared with other urban areas in the state (Lankford, Loeb, & Wyckoff, 2002; Loeb & Reininger, 2004). In Michigan, Harris and Ray (2003) documented that having a qualified teacher based on NCLB standards was highly dependent on students' race, socioeconomic background, and school setting.

It is important to acknowledge that these studies examined the distribution of teacher quality narrowly using teacher preparation and licensure as indicators of quality. Moreover, these studies did not examine the content of policy specifying licensure and certification requirements, standards for professional development, and career support, nor did the studies examine trends at the elementary grades.

Standards, Assessments, and Accountability and Teacher Qualifications Requirements

A comparison of results from studies examining variations in assessments and accountability, such as the studies conducted by Lee (1997) and Swanson and Stevenson (2002), with studies analyzing distributions in teacher qualifications across and within states (e.g., Blank, 2003; Harris & Ray, 2003; Lankford et al., 2002; Loeb & Reininger, 2004) showed states that actively adopted rigorous standards did not necessarily staff their classrooms with qualified teachers, based on indicators of quality stipulated in NCLB such as teacher preparation and certification. The evidence from these studies suggested the most active states undertaking reform performed less well in meeting mandates to staff their schools with qualified teachers when compared with less active states. For example, Kentucky, Maryland, and North Carolina ranked high in adopting both academic standards and assessments according to Swanson and Stevenson's and Lee's analyses. However, in grades seven to twelve, based on Blank's analyses, these states had a shortage of certified teachers. By contrast, Minnesota, New Jersey, and Nebraska were not ranked as strong adopters of academic standards in either Lee's or Swanson and Stevenson's analyses, yet these states' shortage of certified teachers was less severe in comparison with states ranking high in reform policies (Blank, 2003). These results suggest there is a gap between standards touching upon what is expected of students and standards affecting teacher quality, even when such indicators are solely based on certification.

In summary, Southern states such as Kentucky, North Carolina, and Alabama were more likely to adopt strong academic standards and set complex and innovative assessments and accountability policies. The evidence suggests states experienced difficulties in accomplishing mandates related to staffing classrooms with certified teachers, especially those states adopting the strongest policies as well as states with large student enrollments. States with high academic standards and rigorous assessments are not necessarily able to staff a high proportion of their classrooms with certified teachers.

However, we did not find a previous study addressing the emerging gap between mathematics standards and assessment policies and teacher quality policies at the elementary grades in mathematics. This is our focus. Thus, we examine academic standards, assessments, and accountability policies as well as policies governing teacher licensure and certification requirements in mathematics. Using a rigorous process, we compare elementary mathematics assessments and accountability policies and licensure and certification requirements, including professional development requirements. We address each question at national and state levels; we also examine data from California, Florida, and New York to highlight similarities and differences among states.

Defining Teacher Quality

Important conceptual dimensions undergird the concept of teacher quality. Teacher quality encompasses many factors including academic preparation and qualifications, content knowledge, verbal ability, classroom management, and instructional skills, for example. Three subsets of teacher quality are most likely to be affected by state standards on licensure and certification requirements. A first subset of quality is teacher preparation and qualifications, the focus of legislation and related policies. The most frequent measures of quality under this rubric include completion of a bachelors' degree and academic training such as college major and courses taken (Lewis et al., 1999).

A second subset of quality refers to teachers' content knowledge, including general knowledge of the subject to be taught. Policy instruments under this rubric require the prospective teacher meet state licensure requirements including successful completion of one or more licensure examinations to gain certification. In addition there are requirements for on-going, continuous learning through time spent in professional development activities.

A third subset of quality is teaching practices and pedagogical procedures (Hill & Lubienski, 2007). In mathematics teaching practices are the activities and approaches representing core procedures, ideas, and strategies for solving mathematical problems. Teaching practices involve a continuum ranging from strategies emphasizing basic skills to those emphasizing complex thinking (Lewis et al., 1999). Basic skills involve the transmission of factual information to students. By contrast, strategies emphasizing complex thinking encourage students to be active participants in their own learning through collaborative learning and inquiry-based activities. Content knowledge captures the specific ways an individual must understand mathematical concepts, while teaching practices are ways to represent mathematical procedures and ideas such that students learn mathematical content and concepts (Hill & Lubienski, 2007; Hill, Schilling, & Ball, 2004).

Measuring Teacher Quality

A national profile of teachers' qualifications, content knowledge, and teaching practices would provide an understanding of our progress as a nation in affording students equitable access to challenging curriculum and opportunities for closing test score gaps. A profile incorporating all components defining a qualified teacher does not exist. Instead each dimension of teacher quality tends to be studied separately because of data limitations. For example, measures of content knowledge or teaching practices have often been gleaned from studies conducted in specific schools or school districts such as the National Science Foundation's State Systemic Reform and Local Systemic Change, and the Study of Instructional Improvement (SIP). The RAND Corporation conducted several surveys to assess the effects of teaching practices on mathematics achievement in public schools during the course of the National Science Foundation's State Systemic Reform and Local Systemic Change in the 1990's (Berends, Chun, Schuyler, Stockly, & Briggs, 2002; Klein & Stecher, 2000; Leet al., 2006; Stecher & Naftel, 2006). However, these surveys were conducted in specific school districts, and as such they lack national scope. The Study of Instructional Improvement (SIP) conducted by researchers at the Consortium for Policy Research in Education (CPRE) is a longitudinal study of school reform program effects on instruction and academic achievement in a small sample of high poverty urban elementary schools (e.g., Ball & Rowan, 2004; Hill, Rowan, & Ball, 2005; Hill et al., 2004; Rowan, Correnti, & Miller, 2002; Rowan, Harrison, & Hayes, 2004). The SIP study is designed to focus on the nature and quality of instruction and used surveys, classroom observations, interviews, and instructional logs to collect data on instruction from teachers. The survey samples for the SIP study also lack national scope.[2]

National measures on teacher qualifications such as educational attainment, certification, and participation in professional development and licensure exams are available from the School and Staffing Survey (SASS). The 1994–1995 Teacher Follow-Up Survey (TFS) is a follow-up of selected teachers who participated in the SASS and includes some measures on teaching practices. Although nationally representative of teachers and schools, each round of the TFS survey focuses on particular measures of teaching practices, a fact that makes it difficult to examine trends. In addition to some measures on teacher qualifications, the Early Childhood Longitudinal Study (ECLS-K) and the National Assessment of Educational Progress (NAEP) have several measures of teaching practices. However, both the ECLS-K and NAEP are nationally representative samples of students. None of these data include measures on content knowledge or any of the broader set of factors encapsulating teacher quality.

For the current study we focused on the first two subsets of teacher quality—standards of what teachers are expected to know about the subject they teach as reflected in the state's teacher preparation, licensure, and certification requirements. We examined the requirements for professional development which are intended to strengthen teachers' knowledge and skills to teach

[2] Additional information about the Study of Instructional Improvement can be found at the study's web site: http://www.sii.soe.umich.edu/.

to the higher standards expected of students. We also examined the state's provision for in-service continuous career support and mentoring as another form of professional development made available to teachers.

Method

We used a mixed method approach. We qualitatively described the standards, assessments, and accountability policies and the licensure and certification requirements, including professional development, in mathematics; then we compared the policies. Because states adopted several policies affecting their assessment and accountability programs, we derived a composite policy score to determine how states ranked overall. To derive this composite score we applied factor analysis to the assessments and accountability policy variables. The first source of data is a compilation of policies governing mathematics assessments and accountability as well as policies governing teacher licensure and certification requirements in each state and the District of Columbia from surveys conducted by the Council of Chief State Schools Officers from 2001 through 2005. The second source of data is information gathered from each state's department of education certification website (e.g., www.title2.org).

Following previous studies (Lee, 1997; Swanson & Stevenson, 2002), we constructed several variables reflecting what each state has adopted in regards to standards, assessments and accountability using items in CCSSO survey data. We created the following variables: the performance levels used to report students' scores in statewide standardized tests; the type of items included in the assessment, which could be multiple-choice questions only, short- or extended-response questions, or other innovative forms including essays, complex mathematical problems, or projects; whether the assessment results were to be used for instructional purposes; whether the mathematics assessment were to be norm- or criterion-referenced or a non-traditional assessment such as performance-based or portfolio assessments; whether the test results were to be used for accountability; whether the accountability measures were based on results from testing of students, as well as whether results from state standardized test were to be used for student promotion and retention; the extent to which teachers were to be involved in the assessment; the scope of the assessment, indicating whether one test were given to all students; and whether common items were used or whether the state used multiple forms with no common items.

Policies governing teacher quality were coded using state policy documentation supplemented with information from CCSSO surveys. The variables we used to understand states' policies with respect to teacher quality included the following: requirements for elementary school teachers to have a major or a minor in a core academic subject; coursetaking requirements for elementary school teachers during their academic training; and licensure exams administered by the state to new teachers. For the licensure exams we differentiated between the Basic Skills, Professional Knowledge, and Subject Matter Tests. We also coded requirements for professional development participation to renew a license. In addition, from each state's department of education website we obtained information to measure the mathematics competency requirements governing initial certification for elementary school teachers, and the availability of career support and mentoring for teachers.

Standardized assessment/accountability measure

Assessment and accountability policy dataset. We applied factor analysis to student assessment and accountability policy variables for the 50 states and the District of Columbia. Some states had more than one assessment programs in grades one to five. The database was set up by assessment programs; therefore, states with more than one assessment were listed separately for each assessment. We listed each assessment separately because we determined that the policies often differed for each assessment program. In the data we compiled, six states had more than one assessment programs at the elementary level (California, Georgia, Kentucky, Oklahoma, South Dakota, Washington). For example, third graders in California took the California Achievement Tests, a criterion-referenced test; students in second, fourth and fifth grade took the California Standard Tests, a norm-referenced test. Kentucky had the Kentucky Core Content Test (KCCT) for fifth graders and the Comprehensive Test of Basic Skills (CTBS) for third graders. The KCCT is a criterion-referenced test with a combination of multiple-choice and short-response items. In prior studies that examined states' assessment programs, the KCCT was often ranked among the most rigorous assessment programs (Lee, 1997; Swanson & Stevenson, 2002). However, Kentucky's CTBS assessment was a norm-referenced test consisting of multiple-choice questions with one common form given to all third grade students and typically, as we further describe below, ranked much lower than the KCCT assessment. (

Derivation of composite scores. The factor analysis showed that the assessments and accountability policies comprised a single policy dimension.[3] Given that the items comprised a single dimension, we computed one sum composite score using all variables, standardized with a mean of zero and standard deviation of one. The reliability of the aggregate scale was.80, well above the range of acceptable measurement standards. Table 1 rank ordered each assessment program based on the composite score.[4] In cases of more than one assessment program, each assessment program for each state was ranked individually. An assessment and accountability program with a high positive composite score was deemed to be strong overall; an assessment and accountability program with a low composite score or a negative score was deemed to be weak overall. Among the 13 states with the highest composite score for their assessment and accountability program, seven were Southern states (Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, and North Carolina), and four states were in the Midwest (Indiana, Kansas, Missouri, and North Dakota).

Licensure and certification measure

To analyze states' licensure and certification requirements we developed an index to capture the rigor of the mathematics content requirements for certification as an elementary teacher. We used three types of information about state certification requirements: the structure of the teacher preparation, requirements of mathematics courses, and content of mathematics questions in the licensure exams.[5] The goal of the scale was to capture the rigor of the mathematics content knowledge required for certification as an elementary teacher. We more heavily weighted the states that required Praxis II in addition to the Praxis I or similar state certification exam. States receiving a rating of zero (0) did not include a mathematics requirement in their certification document. States specifying a mathematics requirement and required the Praxis I or a similar state assessment received a rating of one (1). States that specified a mathematics requirement and required both the Praxis I and Praxis II or similar state assessments received a rating of two (2). States that specified mathematics requirement as well as testing in liberal arts and science received a rating of three (3).

One can see the implementation of the rating procedure in Florida, where one of the authors completed a teacher preparation program and still maintains certification. Florida outlined

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[3] The appendix provides key selected output from the factor analysis procedure.

[4] North Dakota, Arkansas, Louisiana, Virginia, Arizona, and West Virginia had more than one assessment program. These assessment programs are not shown in Table 1 and appear in the appendix.

[5] Information on the legislation governing teacher preparation was obtained from each state department of education certification website; the reader can access links for those sites from http://www.title2.org.

requirements for three groups of applicants: graduate of a teacher education program, out-of-state certified teacher, and career changer or college graduate of a non-education program. Individuals passing each part of the Florida Teacher Certification Examination (FTCE) who also graduated from a state approved teacher education program qualified for a Professional Florida Educator Certificate. Out-of-state teacher education program graduates and those from other states are issued temporary certification while completing the FTCE requirements. Teachers who are currently certified in another state or who are currently National Board Certified are issued a Professional Certificate if there is a comparable Florida certification subject area. Florida received a rating of two because initial certification required a passing score on a mathematics subtest of the certification examination, and this requirement is in addition to the completion of nine hours of coursework with mathematics content (e.g., methods, mathematics, statistics, or logic). This requirement does not necessarily include courses in mathematics education to teach elementary school students during the pre-service training program.

Results

This section begins with a description of the mathematics standards, assessments, and accountability policies and teacher licensure and certification requirements in mathematics at the elementary school level.

Academic Standards

Since 2005 all states established statewide content standards in mathematics (Blank, 2000; Bormanet et al., 2005; CCSSO, 2005). States' standards establish goals of what students should know and be able to do in mathematics. The mathematics standards provided the basis for decisions on curriculum, texts, instructional materials, student assessments, teacher preparation and professional development, and other components of instruction.

Since the standards are established at the state level, emphasis on what students should know and be able to do varies from state to state. We examined the standards in New York, California, and Florida to illustrate these differences across states. The New York State Board of Regents revised the *New York State Learning Standard for Mathematics* in March 2005, and the standards outlines by grade level what elementary grade students should know and be able to do in five content strands: number sense and operations; algebra; geometry; measurement; and statistics and probabilities. These standards are typically not viewed as particularly stringent (Finn & Kanstoroom, 2001), even in analyses that quantified and compared the policies with those of other states (Lee, 1997; Swanson & Stevenson, 2002).

California's *Mathematics Content Standards* and the state's academic standards in general have typically been praised for clarity and comprehensiveness, and they have been commonly acknowledged to be very strong (Finn & Kanstoroom, 2001; Stecher & Naftel, 2006). The content strands are similar to New York, but there are important differences in what is expected of students at different grade levels. For example, in second grade California students are expected to memorize multiplication tables, but in New York second graders are only expected to show "readiness" for multiplication. It is unclear however what level of skills constitutes readiness. In California second graders are expected to recognize and compare unit fractions; New York's standards do not articulate such expectations for second graders. In California students begin to learn to add and subtract fractions in third grade, and they are expected to conduct a simple probability experiment in third grade as well, while in New York the concepts of probability are not introduced until the fifth grade. In fourth grade, California's students are expected to understand perimeter, volumes, and areas of simple objects.

In 1996, the Florida Board of Education adopted a set of *Sunshine State Standards*, which the state department of education had developed with Florida educators and made available for review by each school district before official adoption by the state Board of Education.[6] Unlike California and New York, whose standards are articulated for each grade, Florida's standards are divided into four grade clusters (Pre-K–2; 3–5; 6–8 and 9–12). Over the years Florida has instituted grade level expectations (GLEs) in subject areas, including mathematics. These GLEs in turn inform state assessments in grades three through ten in mathematics as well as in reading. The GLEs were developed to match the standards to national trends because most states were setting their standards by grade. As an example, the expectations for first grade are that Florida students know basic addition and subtraction facts, and by second grade students are expected to recall addition facts and demonstrate knowledge of multiplication and division, a set of expectations also articulated in California. The concepts of chance and probability are introduced in the K–2 cluster. By third grade the expectation is that students in Florida will be able to represent possible outcomes for a randomized event using charts and to also calculate the probability of an event from a set of possible outcomes.

Assessments and Accountability

Although standards varied among states, testing of students seemed to follow a similar pattern across states. Since NCLB was enacted, more states started testing earlier and more frequently throughout the elementary grades. Key similarities across states are frequency of student testing and the type of items included in the assessment at the elementary level. Fourth graders are most frequently tested, followed by third and fifth graders. Forty-four states have a fourth grade mathematics assessment; 26 states have a third or fifth grade mathematics assessment. The District of Columbia and Utah began annual testing in first grade; Arizona, California and Mississippi began annual testing in second grade (CCSSO, 2000, 2002). The number of states testing three or four times between grades one and five has doubled. As of 2005, 24 states were testing once or twice between grades one and five; the remaining states were testing more frequently (CCSSO, 2005).

We found increasing homogeneity in the types of items included in state assessments. Twenty-three assessments contained all multiple-choice items, and another 33 assessments contained a combination of multiple-choice items with short-response items, while two assessments had no multiple-choice items. Often items included in assessments correlated with frequency of testing in the state. States that assessed students in several grades tended to use assessments with multiple-choice items. Performance-based assessments that included extended-response items were previously used in Maryland and North Dakota as late as 2001. These assessments are no longer used in either state (Merrow, 2007). These types of assessments are regarded as expensive to administer; as a result states are less inclined to use them. An exception to this trend and a possible indicator of how future assessments might be conducted was the creation of the New England Common Assessment Program (NECAP) an ongoing consortium consisting of the states of Rhode Island, New Hampshire, and Vermont. Together they were undertaking a performance-based assessment using materials developed by WestEd (K. Comfort, personal communication, November 16, 2004).[7]

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[6] Each of Florida's 67 contiguous counties is a school district with a variety of specialty schools also considered individual school districts (e.g., School for the Deaf and Blind; Florida Atlantic University Laboratory School; Florida State University Laboratory School).

[7] Maine will join the consortium this year (K. Comfort, personal communication, August 12, 2009).

Current assessments do not track progress in specific content areas, a weakness in terms of identifying student progress in specific content areas (Linn, 2000). Expectations of what students should know are defined by specific content areas; for this reason it is important to track progress in each content area rather than in the aggregate, since aggregate test scores mask important differences in students' progress across specific academic skills and content areas. Several studies illustrated the variance in students' rate of progress in specific content areas. Given such variance studies often reported narrowing test score gaps in some skills while the score gaps worsened in other skills in the same subject over the course of the school year (Georges, 2007, 2009; West, Denton, & Germino Hausken, 2000; West, Denton, & Reaney, 2000). It will be important to understand students' progress in specific content areas to determine how to effectively target instructional resources.

We next examined how states combined different policies affecting their assessment programs. Criterion-referenced tests were more prevalent than norm-referenced tests—54% of the assessments were criterion-referenced tests, while 27% were norm-referenced test. Assessments were increasingly standards-based in that some portion of the assessments addressed subsets of the state's academic standards. Norm-referenced tests were more likely to include all multiple-choice items while criterion-referenced tests tended to have a combination of multiple-choice with short-response items.

Table 1 rank orders each assessment and accountability policy set based on the composite score for each state. Southern states with assessment programs with a high overall ranking tended to score low because the assessment infrequently addressed the academic content standards, and whether norm- or criterion-referenced, assessments often included primarily multiple-choice items, or used multiple forms with common questions to test all students. States that did score high in the composite policy score were not concentrated in any specific region (Maryland, Kentucky, Pennsylvania, Oregon, Idaho, North Dakota, and Nebraska). The data suggest that the factors that propelled assessment programs in states like Maryland, Kentucky, North Dakota, and Oregon to the top were those factors addressing at least a subset of a state's academic standards and used multiple forms without common questions, combining multiple-choice items with some non-traditional assessment approach. Teachers were also more likely to be involved in developing the assessment in these instances.

Table 1
State's rank and rating in student assessment and accountability

Rank	Assessment Program	State	Policy Score
1	Missouri Assessment Program (MAP)	MO	14.4
2	NC Annual Testing Program	NC	13.9
3	Delaware Student Testing Program: Standards-Based Testing	DE	11.9
4	Maryland School Performance Assessment Program (MSPAP)	MD	11.5
5	Reading, Writing, Mathematics, and Science	OR	8.8
6	KCCT On-Demand	KY	8.7
7	Kansas Assessment Program	KS	8.5
8	Massachusetts Comprehensive Assessment System (MCAS)	MA	7.4
9	LEAP 21	LA	7.2
10	Florida Comprehensive Assessment Test	FL	6.8
11	Direct Math Assessment	ID	5.8
12	Criterion-Referenced Competency Tests (CRCT)	GA	4.7
13	North Dakota Mathematics and Reading Tests	ND	4.0
14	4th-Grade Proficiency Testing	OH	3.6
15	Wisconsin Knowledge and Concepts of Examinations (WKCE)	WI	3.1
16	Criterion-Referenced Testing: Benchmark Exams	AR	2.6
17	Illinois Standards Achievement Test (ISAT)	IL	2.4
18	New York State Testing Program	NY	2.4
19	Connecticut Mastery Test (CMT)	CT	2.3
20	Maine Educational Assessment	ME	2.2
21	Criterion-Referenced Testing (Standards-based Testing)	AK	2.1
22	NM Achievement Assessment	NM	1.7
23	NH Educational Improvement and Assessment Program	NH	1.6
24	Criterion-Referenced Tests—PACT grades 3–8	SC	1.5
25	Statewide Assessment	IN	1.2
26	Achievement Test (3–8)	TN	1.0
27	Standards of Learning (SOL) Assessment Program	VA	0.9
28	Norm-Referenced Testing (TerraNova)	NV	0.9
29	Utah Core Criterion-Referenced Tests (CRTs) Program	UT	0.9

Rank	Assessment Program	State	Policy Score
30	New Standards Reference Exams (NSRE)	VT	0.2
31	Elementary School Proficiency Assessment (ESPA)	NJ	0.0
32	Grade 4 and 7 Reading and Mathematics	MI	-0.3
33	Minnesota Comprehensive Assessments	MN	-0.3
34	Wyoming Comprehensive Assessment System (WyCAS)	WY	-0.3
35	English Language Arts and Math Performance Assessment (New Standards Reference Exams)	RI	-0.8
36	Standardized Testing ITBS and ITED	IA	-0.8
37	State-Developed Alternative Assessment (SDAA)	TX	-0.8
38	Reading, Writing, Mathematics, and Science	CO	-0.9
39	Washington Assessment of Student Learning (CRT)	WA	-0.9
40	Stanford Achievement Test, Ninth Edition	DC	-1.2
41	Oklahoma Core Curriculum Tests—Multiple-choice	OK	-1.3
42	Mississippi Curriculum Test	MS	-1.8
43	Reading, Mathematics, Writing	PA	-1.8
44	Stanford Achievement Test, Ninth Edition	AL	-2.1
45	National Norm-Referenced Test (CTBS/5)	KY	-2.4
46	Stanford Achievement Test, Ninth Edition	SD	-4.1
47	Student Assessment Requirement	MT	-4.2
48	Standardized Testing and Reporting Program (STAR)	CA	-4.9
49	School-Based Teacher-Led Assessment and Reporting System (STARS)	NE	-5.5
50	CRT: Arizona's Instrument to Measure Standards (AIMS)	AZ	-6.9
51	SAT9 Norm-Referenced Test	WV	-10.7
52	Stanford-9	GA	-12.5

Authors' calculation based on survey data from Council of Chief State School Officers, various years. Georgia and Kentucky had two assessment programs. There were insufficient information to rank the second assessment for California (California Achievement Test CAT/6 used in 3rd grade), Oklahoma (Stanford 9 Achievement Test used in 3rd grade), South Dakota (Dakota STEP used in grades 3–5), and Washington (Iowa Tests of Basic Skills used in 3rd grade). North Dakota, Arkansas, Louisiana, Virginia, Arizona, and West Virginia had more than one assessment program. Their composite score appears in the appendix

Licensure and Certification Requirements

Degree and mathematics courses requirements. Every state required elementary school teachers to complete a bachelor's degree. Some states specified the type of courses that prospective teachers must complete during their pre-service training. The most frequent requirements were for prospective teachers to complete general education courses for their baccalaureate degree. In 2005, 19 states required elementary school teachers to major in a core academic subject, and two additional states required either a major or a minor (CCSSO, 2005). While the requirement for degree completion and course requirements may be met, every elementary school student does not have a teacher with the requisite mathematics content courses.

The policy governing how elementary teachers demonstrate preparation in academic subjects includes course credits in core fields, state-defined standards, or attending and graduating from an approved teacher education program. A review of the course credit requirements showed three states specified pre-service training with minimum credits in mathematics specifically (Indiana, Mississippi, New York). For example, Florida and Louisiana required nine hours of courses that had mathematics content, not necessarily courses in mathematics education relevant for teaching elementary grade students. It was more typical for states to specify course credits across different content areas, with mathematics being among one of several areas to choose from. For example, Connecticut's course requirements were specified as 39 credits in five of six content areas. Mathematics was listed as one of the six content areas, suggesting perhaps that the credit requirements can be met without taking any mathematics courses.

Licensure requirement. States were more likely to change the standards for licensure affecting prospective teachers than was the case for in-service teachers. This was most visible in the number and types of exams prospective teachers must pass to demonstrate competence in their teaching field and receive their license (CCSSO, 2002, 2005). The basic skills test, the professional and pedagogical knowledge, and the subject-matter tests were used for licensure across most states. Table 2 shows which of the licensure exams states used. Most states (43 states) required prospective teachers to pass at least two of the three written tests to secure their license (the basic skills and the professional knowledge tests). The Educational Testing Service (ETS) Praxis was most frequently used to assess prospective teachers on their basic skills and professional knowledge; 31 states used the ETS Praxis I. Thirty-four states required new teachers to pass the ETS Praxis subject matter competency exam. Six states required only the subject matter competency licensure exam. Figure 1 shows the geographic distribution of which licensure exams states required for the initial certification. As shown, 12 states developed their own licensure exam. States typically relied on available tests like the Praxis series, with the majority of states using the Praxis series exams to assess prospective basic skills, professional knowledge, and subject content competency.

Table 2
Initial certification and renewal requirements

Policy issue	State
Basic skills and professional knowledge test	
ETS Praxis I	AK AR CT DE DC ID IN IA KS KY LA ME MD MN MS NE NV NH NC ND OH OK PA SC SD TN TX VT VA WV WI
State Assessment	AL AZ CA FL GA IL MA MI NM NY OR WA
Subject Matter Competency	
ETS Praxis II	AL AR CO CT DC HI ID IN KS KY LA ME MD MN MO MS NE NV NH NJ NC ND OH PA RI SC SD TN UT VT VA WV WI WY
Professional development (5 year period)	
Minimal (less than 6 semester hours/60)	HI ME MO NE TN ND OK WY
Modal (6 semester hours/120 professional development contact hours)	AK AL AR CO CT DE DC FL GA IA ID IN MD MA MI MS MT NV NJ OH OR SC SD UT WV WI
High professional development requirements (more than 120 professional development contact hours)	AZ CA IL KY KS LA MN NH NM NY NC PA RI TX VA VT WA
Induction and Mentoring (State mandated)	
First-year programs (Induction)	AR CO DC FL ID KY NJ OH OK OR PA MS ND NE NY SC VA WV
Programs beyond one year	AL AZ CA CT DE GA HI IL IN IA KS LA MA MO NC NJ NM RI TX UT
Require professional development plan	ME MD MI NH TN VT WA WI

Authors' compilation from Council of Chief State School Officers surveys, various years, from http://www.title2.org and state departments of education websites.

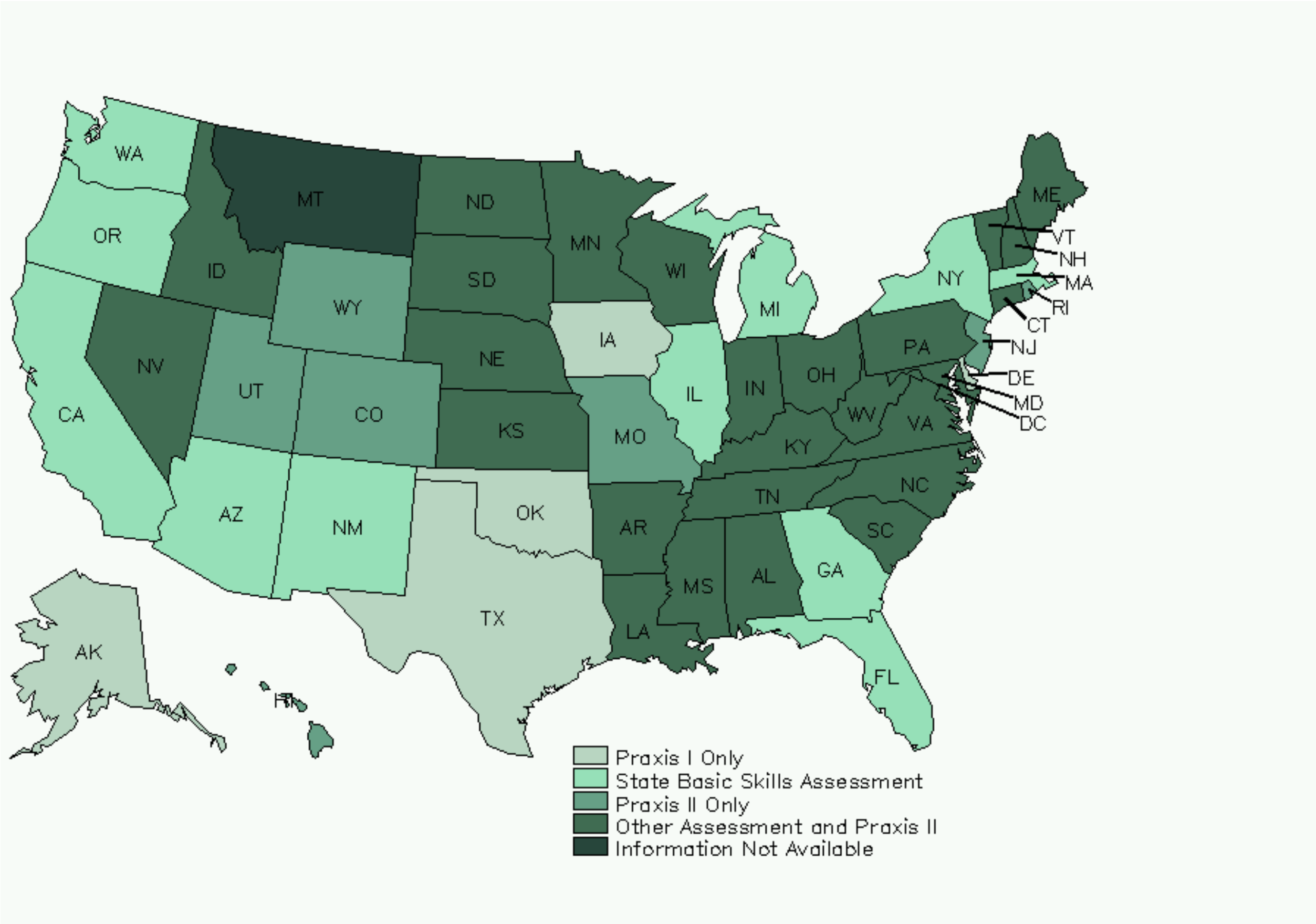

Figure 1. Licensure exams for initial certification.

Rigor of mathematics content requirement. Licensure is a proxy for mathematical knowledge, and the NMAP Report pointed out that the Praxis exams vary in the amount and level of mathematical knowledge assessed. The NMAP Report concluded that teachers need to know the content they teach, the connection of that content more broadly to later grades, and understand the mathematics prior to the content they are responsible to teach in addition to the content that follows. We used several sources of information to determine whether the licensure and certification requirements states adopted promoted mathematics content knowledge. Our approach to make this determination involved evaluating the requirements for the initial professional certificate in terms of the mathematics courses required and reviewing the type of mathematics questions in the licensure exams for each state.

In our review of the requirements for the initial professional certificate we looked at the structure as well as the legislation governing teacher preparation. In most states this process was described in terms of three groups of prospective teachers: graduates of a state's teacher preparation programs, graduates of out-of-state preparation programs, and experienced teachers from another state seeking certification in a new state. We determined the mathematics course hours required to obtain a baccalaureate degree in elementary education (three or six credit hours seemed to be the most frequent requirements); in other states there were mathematics teaching methods course requirements.

We considered which licensure exam was used to assess content competence in mathematics of elementary teachers. As shown in Table 2 some states created their own licensure exam while other states participated in the ETS Praxis series. Where available, we reviewed a sample of the mathematics questions in those exams to determine the level of content knowledge required to pass the exam. It would have been ideal to review the actual exam questions. We were able to examine only practice questions available online. Although these were not actual exam questions, we believe that because these questions were intended to assist examinees in preparing for the exam, these practice questions were representative of types of questions in the administered exam.

The mathematics questions in the basic skills and subject-matter Praxis tests and in state-developed tests are intended to measure competency in mathematics and in general seemed not to be rigorous. These questions required teachers to demonstrate minimum knowledge of content competence in mathematics. There were some exceptions. The sample questions we examined in the New York and Oregon exams included mathematics questions demanded a high level of competency and were more stringent than questions included in the Praxis tests or in other state tests.

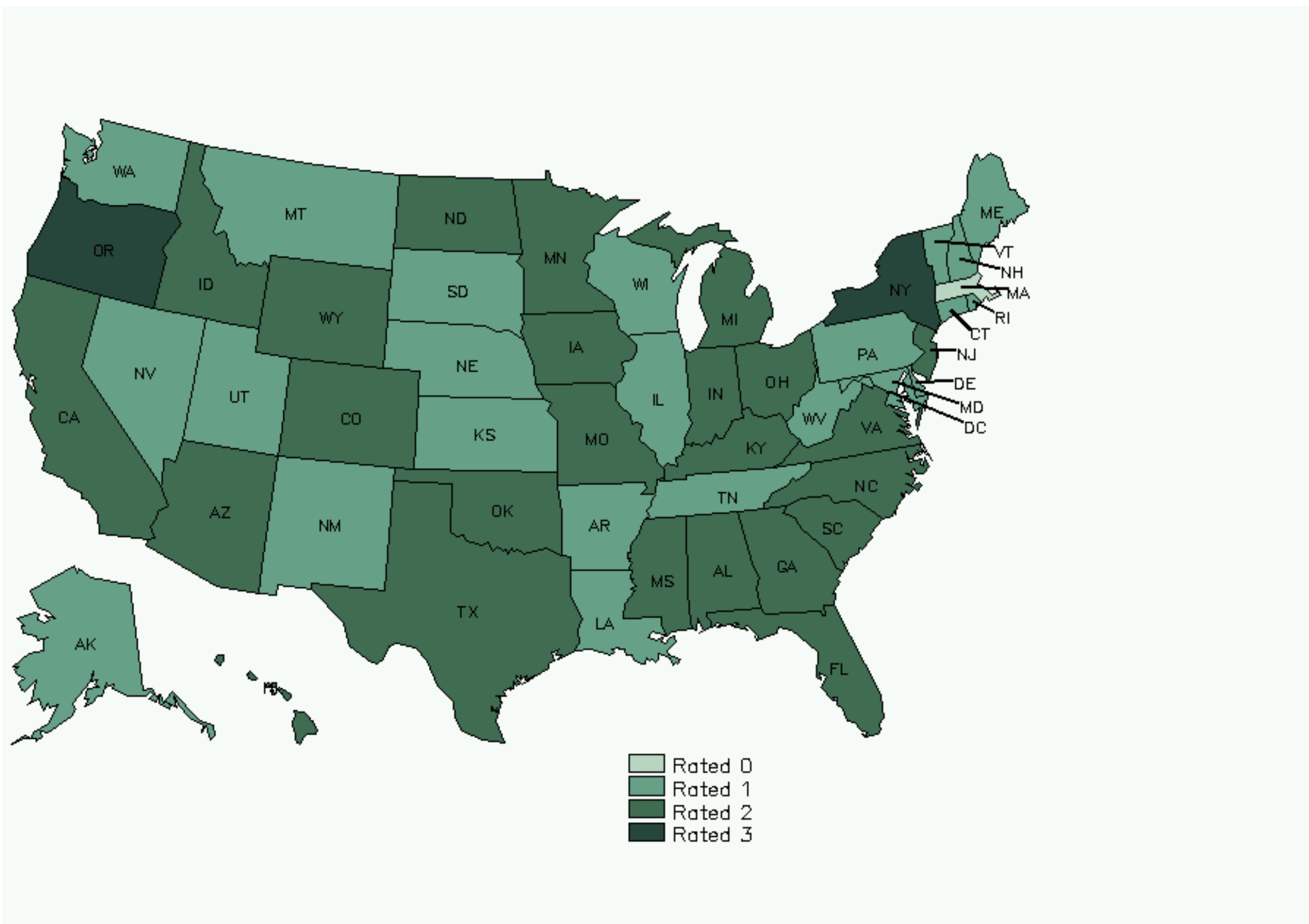

Figure 2. Rigor of mathematics requirements (0–3 scale).

The map in Figure 2 shows each state's licensure/certification rating. The single state rated zero is Massachusetts, which had no mathematics course requirements.[8] Two states (New York and Oregon) received a rating of three, which indicates that both states specified mathematics courses during pre-service training and also that their licensure exam demanded high level of competency in mathematics when compared to other states' licensure exam. Twenty-four states including California, Florida, and Texas received a rating of two.

The variation in rigor of mathematics requirements could result in substantial inconsistency in teacher quality across states. New York and Oregon are identified as having rigorous mathematics content requirements at the elementary grade level, reflected in the difficulty of the mathematics questions in each state's exams, and one might expect these states to have teachers rigorously prepared in mathematics when compared to other states. By contrast, Delaware and Massachusetts are identified with the weakest mathematics content requirements and would be expected to have teachers unlikely to be thoroughly prepared to teach mathematics in contrast to teachers trained in comparison states. The implications are twofold. First, elementary school students in such states could be better positioned to achieve to higher standards given the higher expectations for teachers' mathematics content requirements. Second, having rigorous mathematics content requirements could result in these states experiencing greater difficulty recruiting and retaining teachers who meet these requirements.

Professional development and mentoring. Extensive formal preparation with the completion of an academic degree does not guarantee that teachers will acquire the mathematical content knowledge or the pedagogical skills to teach mathematics. Teachers' content knowledge in line with challenging state standards can be sustained through regularly scheduled in-depth participation in professional development activities (Corcoran, 2007; Garet, Porter, Desimone, Birman, & Yoon, 2001). A primary goal of providing opportunities for professional development is for teachers to develop skills in implementing standards-based instruction, selecting and using appropriate materials and instructional practices to enable students to achieve at the highest levels as those aligned with appropriate standards.

We examined states' requirements for certification with an eye toward identifying requirements that would enhance elementary teachers' mathematics teaching practice. In concert with the other areas included in Table 2, initial preparation requirements and mentoring efforts to improve practice, we conclude that states have not placed much effort in improving elementary teachers' practice either through their initial preparation requirements or through mentoring efforts. Despite the suggestions of the NMAP report to assure teachers prepare their students for success in algebra, we found little in the professional development requirements that suggests this warning has been taken to heart.

Based on available data, state policies regarding requirements for professional development have not been significantly altered and typically are measured with respect to credit hour requirements rather than with specific content requirements. States phrased professional development requirements as completion of credit hours, continuing education units, college course credits, attending workshops, or completing portfolios. Every state has requirements for certification that mandates participation in professional development activities within a span of three, five, or ten years (the time frame depending on the state). Using information on number of hours or assigned course credits we identified three categories of professional development requirements: minimal requirements of less than six semester hours or 60 professional development hours, modal

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[8] Requirements for initial elementary teacher certification and renewal have changed since we began this study.

requirements of six semester hours or 120 professional development hours, and high requirements, more than 120 professional development hours.

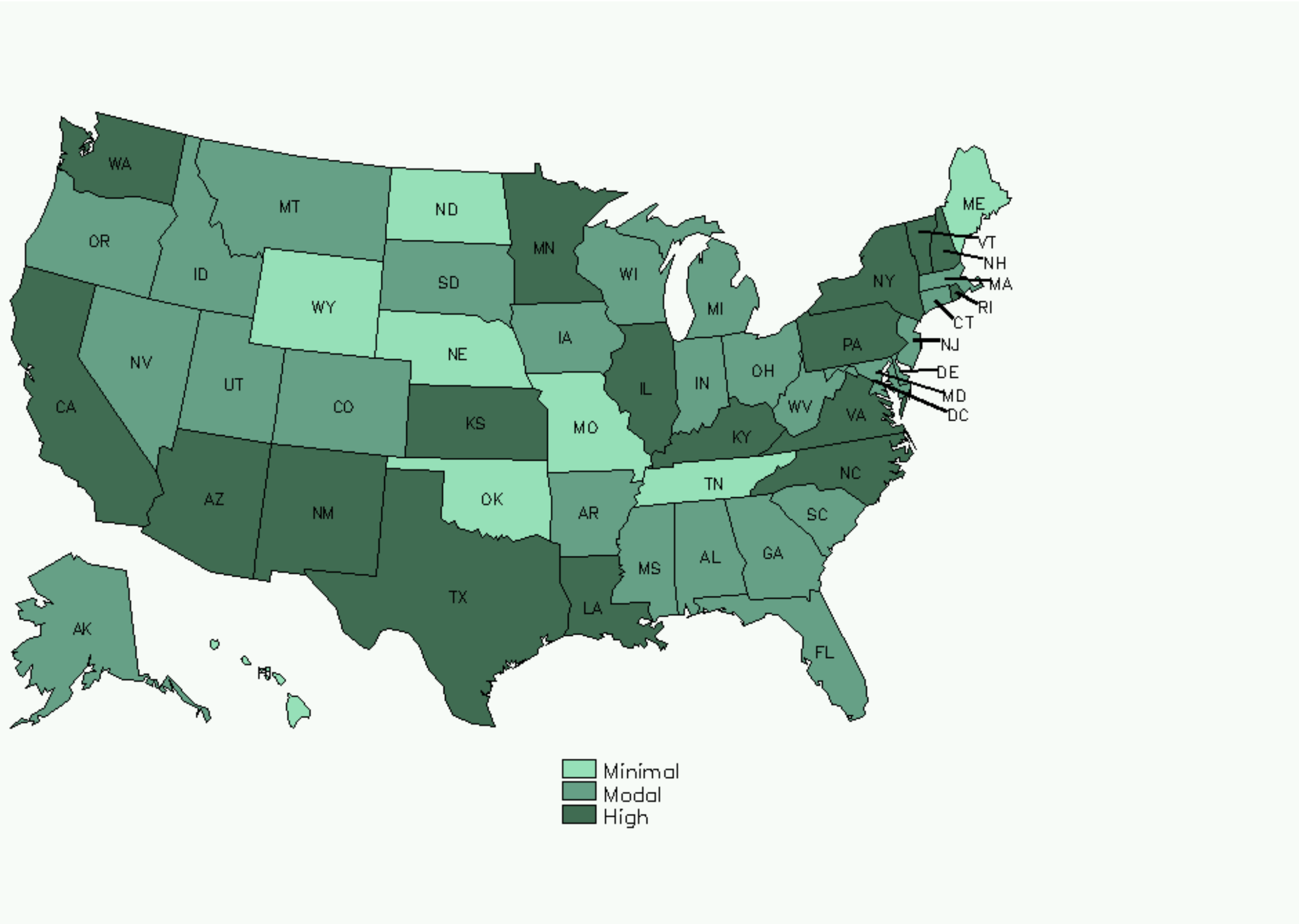

Figure 3. Professional development requirements.

The states are organized by the three categories of professional development requirements in Table 2 and illustrated in a map in Figure 3. Eight states are in the minimal requirements category, and 17 states are in the high requirements category. New York, Texas, and Kentucky are examples of states that have high requirements. New York requires 170 hours of professional development activities every five years. Texas' requirements range from 150 to 200 hours every five years. Kentucky's requirement is based on years of employment. In Kentucky during the first five years of employment, teachers renew their license after completing 15 graduate hours of courses; in the second five years teachers renew their licenses after completing at least 32 graduate hours of courses (CCSSO, 2005).

Often states explicitly stipulate that professional development activities must be related to the teaching assignment. The challenge facing elementary teachers is one that requires a single teacher typically to be responsible for teaching all subjects—social studies, language arts, and reading as well as mathematics. The current structure for meeting professional development requirements does not necessarily translate into strengthening teachers' mathematics content knowledge because a gulf exists between how broadly professional development requirements are articulated and the general teaching assignment requiring elementary school teachers to teach every subject. Student academic standards are articulated by content areas, while professional development requirements and pre-service training during college are broadly constructed and do not specify the mathematics content elementary teachers are expected to know for teaching. This is a disconnect with severe consequences for teacher quality and student learning outcomes in mathematics.

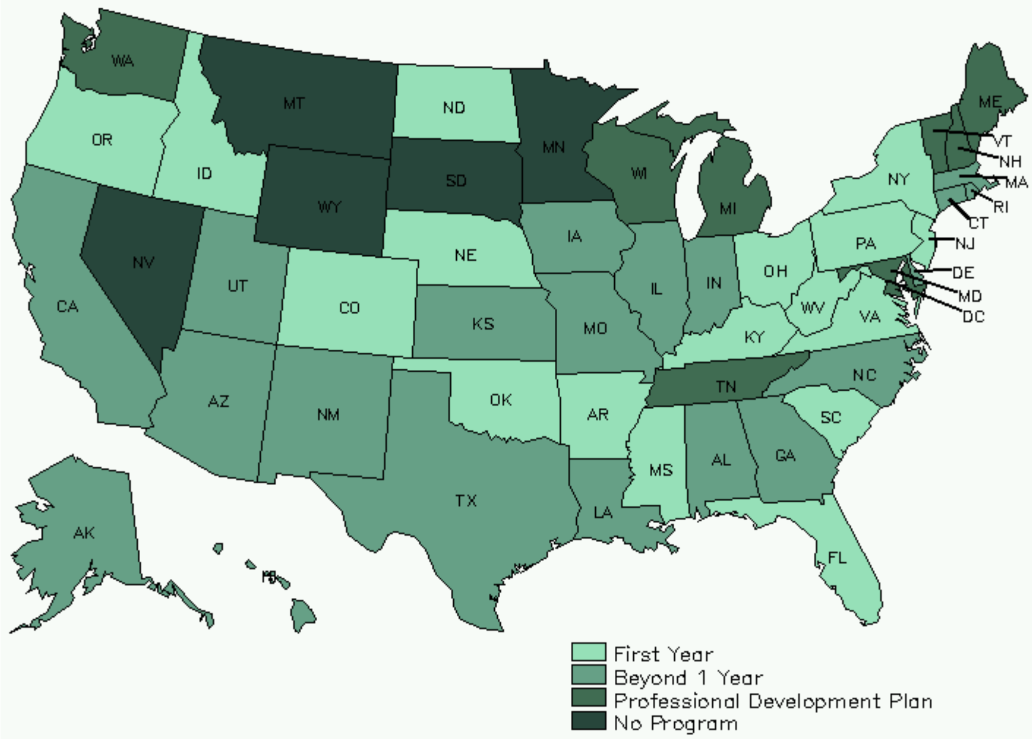

Figure 4. Induction and mentoring program and professional development plan.

As a supplement to professional development several states have implemented induction programs for first-year teachers, and some states have begun mentoring programs. All but five states implemented some form of induction and mentoring programs for new teachers, as illustrated in Figure 4. These programs were most frequently available in the first two years, with 38 states implementing one- or two-year induction and mentoring programs. In recent years as school districts aim to improve retention and ensure that new teachers are inducted into the profession with mentoring and an eye to the future, the professional development plan has increasingly become a part of becoming a professional, a teacher who strives to improve his or her practice through a long-term plan of structured activities. Figure 4 shows the eight states that implemented a professional development plan (Maine, Maryland, Michigan, New Hampshire Tennessee, Vermont, Washington, and Wisconsin). Upon review of these procedures as well as the contents of these programs, none had any provisions that were intended to provide support to strengthen elementary teachers' mathematics content knowledge. There is limited evidence that mathematics instruction could improve through current professional development policies, whether or not those activities include a professional development plan. For example, Florida law mandates the development of an individual plan connected to school improvement goals at the district level. In collaboration with their principals and other instructional staff, teachers are supposed to develop a plan to improve their individual practice to ensure success for all students. However, district professional development staff have explained that the statutory requirement leaves implementation and monitoring as a district responsibility (M. Meacher, personal communication, August 12, 2009).

Links between assessment/accountability and licensure/certification

We now turn to the relationship between assessments and accountability, on the one hand, and the teacher licensure and certification requirements in mathematics at the elementary school level, on the other. For educational reform to be effective there should be a seamless system whereby each component of this system is aligned to maximize the quality of students' academic experiences. As such, feasible connections should exist between what students are expected to know and the preparation and qualifications expected of teachers. In other words, if a state has specific student academic standards aligned with the state's accountability system, then state policies should strive to have well prepared teachers who possess qualifications commensurate with what students are expected to know and learn.

Changes in licensure and certification were more likely to affect prospective teachers than in-service teachers, and these changes are not aligned with student academic standards. Requirements for pre-service training and changes in the types and contents of licensure exams affect new teachers. On the other hand, changes in the requirements for recertification and on-going professional development for current teachers have been less frequent. The requirements for re-certification are generally on the order of completion of six credits or courses or completion of 120 to 150 hours in any combination of professional development activities over a period of some years, typically five years, an obligation equivalent to a minimum of 24 to 30 hours per year in professional development activities. There are no specific requirements as to the content of the professional development activities, a lack of structure that is problematic at the elementary level considering that elementary teachers must teach every subject. In the absence of policy guidance, there is no assurance that hours in spent in professional development will translate into more mathematics content knowledge that informs instructional practices (Corcoran, 2007). With scant changes in policy specifying content requirements for professional development for license renewal, a large proportion of the elementary teaching force will likely remain unaffected, thus weakening the impact of state policy on teacher quality.

We compared how states rank in assessments and accountability policies with our measure of mathematics content requirements for licensure/certification. The mathematics content requirements for Missouri, North Carolina, and Kentucky teachers were moderately rigorous, each state receiving a score of two, yet these states ranked among the top ten states in assessments and accountability policies (see Table 1), meaning that expectations for students' mathematics standards were very high in those states. New York's mathematics content requirements were deemed very strong, a rating of three, but the state ranked moderately in assessments and accountability policies, at least at the elementary grade levels. Oregon is an exception in that the state's mathematics content requirements were very strong and the state also ranked among the top ten states in assessments and accountability policies. This suggests that Oregon's expectations for students and teachers were somewhat aligned compared to other states.

Discussion

The findings pertaining to state policy rankings confirmed patterns that Swanson and Stevenson (2002) observed in the 1990s. In addition, the patterns Lee (1997) observed in the 1980s has persisted in that Southern states continued to maintain strong assessment and accountability policies. Unlike the analyses of these researchers, however, we showed these states' assessments and accountability policies were driven by expectations for students' performance. Southern states tended to be weaker compared with other states on the types of items, the scope of the assessments, and the involvement of teachers with the assessment program.

We analyzed the different requirements for licensure and certification, and we also assessed the mathematics content requirements for elementary teachers. We showed a lack of rigor in the expectations of mathematics content knowledge for elementary teachers. There was a lack of specificity in the requirements for professional development, the main vehicle through which mathematics content knowledge can be improved. The differences between expectations for students and expectations for teachers mathematics content knowledge means that teachers may not have the content knowledge to teach to the standards required of elementary students. This gap means that students may not gain the mathematical foundation necessary for later achievement in mathematics.

Academic standards do not cohere well with policies for teacher quality, including pre-service training, the licensure exam, and requirements for professional development. Pre-service training including mathematics coursework and the content competence required in licensure exams does not strongly promote mathematics content knowledge. States generally do not require elementary teachers to complete a minimum set of mathematics course hours during their pre-service training, nor do states generally include rigorous sets of questions in their licensure exams to determine the content competence in mathematics.

States with strong student academic standards and even those states with strong standards guiding teacher preparation programs do not have in place policies to support professional development activities that will improve and promote teachers' mathematics content knowledge. We do not address the question of whether the number of hours teachers currently spend in professional development is sufficient to accomplish improvement in mathematics content knowledge, and we do not address the quality and depth of professional development experiences. However, based on information from available documents we can ascertain that stipulating credit hours or hours in professional development over some period of years does not address the core of what professional development should be—specifically, the importance of engaging teachers in activities that improve their skills and knowledge in content areas their students are expected to learn and master.

It is perhaps both unfeasible and impractical to suggest that elementary teachers must major in mathematics or that they should have a solid foundation covering complex content knowledge in mathematics. The NMAP Report concluded that students' preparation for successful completion of algebra implies that students should be fluent with whole numbers, fractions, geometry, and measurement. On the basis of this recommendation elementary teachers must be able to provide the conceptual and procedural knowledge for students to develop these skills. Given the national goal that students must be successful in algebra, it is therefore practical to expect that elementary teachers should have ongoing opportunities to improve their content knowledge of how young children learn whole numbers, fractions, geometry, and measurement that are the foundation for the mathematics learned in middle and high school. Requiring specific mathematics course hours at the pre-service level would be most helpful; continuous and more intensive professional development for teachers to improve their instructional skills appropriate for these mathematics skills is also important. However, accumulating hours in professional development is insufficient, and participation in fragmented, low-quality professional development is undesirable (Corcoran, 2007). Rather, the concept of additional professional development assumes that available resources are used efficiently such that training produces desired change in teachers' content knowledge and teaching practices and ultimately contributes to improvements in student academic achievement (Corcoran, 2007). We hope that policies on professional development would clearly articulate the specific pre-service mathematics courses as well as provide the support to in-service elementary teachers to improve their mathematics content knowledge. In essence, expectations for teachers should be aligned with expectations for what students should know.

Two major challenges confront policy makers in changing professional development requirements. The first concerns the costs associated with increasing the amount of professional development activities engaging in-service teachers. In addition to the direct costs including salaries of district and school administrators, substitute teachers, and materials and supplies, teachers are typically compensated with higher salaries for undertaking additional professional development (Killeen, Monk, & Plecki, 2002). These are formidable expenses for states and districts challenged by difficulties faced in carrying out essential services. The second challenge concerns indirect costs borne by students in reduced instructional time with their regular teachers. One policy that could be considered is alternative approaches to professional development whereby those activities are integrated into the instructional day, and also where states and districts make mentoring an integral part of the profession rather than the short-term program it seems to be now.

The methodological approach we presented is readily applicable to other academic subjects and different grade levels. Our method could also be employed to conduct cross-subject comparisons. Yet our study has limitations. We did not analyze how licensure standards and certification requirements cohere with changes in curriculum and teaching practices, the primary vehicles for educational reform to enhance student learning. As such our analysis is only a first step in understanding the relation between current licensure standards and the changes in teacher quality. In future research, researchers should examine the effects of competency requirements and licensure standards on student mathematical achievement across states. Such research could then address such topics as the implications for mathematics achievement in states where teachers are involved with the assessment.

It is not simply changes at state levels that matter. Although policy and reform mandates are centralized at state and federal levels, implementation is delegated to schools. As such, leadership in school districts could be an important link in schools' capacity to staff classrooms with qualified teachers. School districts filter and shape information about state policies, and districts also set the context for coherent alignment between school practices and those intended by the state (Spillane, 1996; Spillane & Thompson, 1997). This can be a recipe for failure. Analyses conducted by Spillane (1996) showed how school districts in Michigan shaped the success or failure of state policy mandates. In Michigan, for example, Spillane showed outcomes were frequently determined by the availability of opportunities for professional development activities in response at the local level to adoption of state policies. In understanding variations in the implementation of assessments and accountability measures and licensure standards and certification requirements, variations among districts with different student populations should be in the focus of future research.

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Appendix: Technical notes

Selected output from the factor analysis procedure

The KMO and Bartlett's Test. The KMO measure indicates how well the data are suited for factor analysis. The KMO measure is the ratio of the sum of the squared correlations for all variables in the analysis to the squared correlations of all variables plus the sum of the squared partial correlations for all variables. Small values of KMO indicate that factor analysis many not be appropriate for the data. KMO values higher than .5 are above acceptable values to proceed with factor analysis. The KMO measure for our data is .69. The Bartlett's test of sphericity is a measure that is asymptotically distributed approximately as □^{2}, and it can help determine whether the correlation matrix among all variables in the analysis is an identify matrix; that is it indicates if there is a relationship among the variables. The Bartlett's test statistic for our data is 369.4 with 105 degrees of freedom, statistically significant below a p of .01, which allows us to reject the hypothesis of an identity matrix. In other word, there is a relationship among the variables.

Total variance explained. Table A1 shows the derived components of variance for both the initial eigenvalues and rotated components. The first component accounts for most variance (28.4%), the second component accounts for the second greatest variance (11.7%), etc. The first five components account for 68.4% of the variance in the data. Based on this table five components can be extracted because five have eigenvalues greater than one.

Table A1
Variance distribution by component

Component	Initial eigenvalues			Rotation sums of squared loadings		
	Total	% variance	Cumulative	Total	% variance	Cumulative
1	4.3	28.4	28.4	3.5	23.6	23.6
2	1.8	11.7	40.1	2.1	13.9	37.4
3	1.7	11.6	51.6	1.8	11.8	49.2
4	1.4	9.3	60.9	1.5	9.9	59.2
5	1.1	7.4	68.3	1.4	9.2	68.3
6	0.9	6.3	74.7			
7	0.8	5.5	80.1			
8	0.7	4.9	85.1			
9	0.6	4.0	89.1			
10	0.5	3.3	92.4			
11	0.4	2.8	95.2			
12	0.3	2.2	97.4			
13	0.2	1.3	98.7			
14	0.1	0.8	99.5			
15	0.1	0.5	100.0			

Scree plot. The scree plot helps to decide how many components to select. The eigenvalues are on the vertical axis and the component numbers are on the horizontal axis. A Transition from high eigenvalues to small values helps to decide the number of components to select. The scree plot below shows a bend at the first factor, which suggests a one-factor solution.

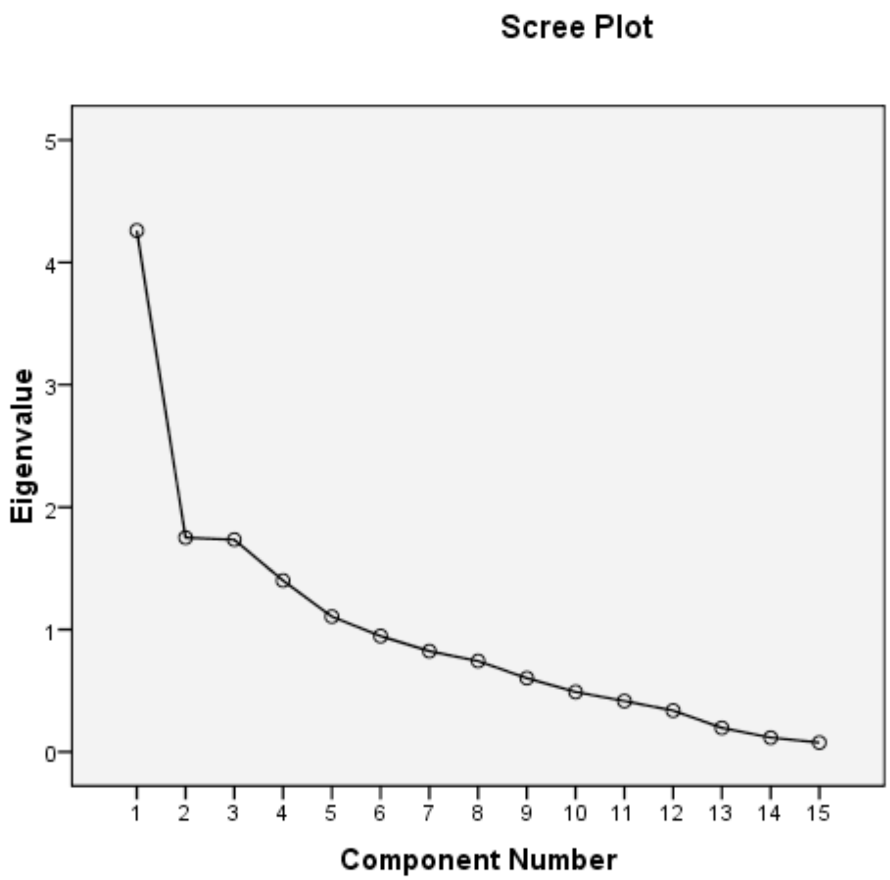

Figure A1. Eigenvalue by component.

Factor loadings. Table A2 shows the factor loadings for each variable. Almost all variables load onto the first components in the component matrix. Table A3 shows factor loadings for the rotated components, a clearer separation among the variables.

Based on the factor analysis results, we created a sum composite score using all variables. We also examined which of the component contributed the most to the overall policy score. To do so we created four sub-scores. The first sub-score includes four variables: relation of assessment to content standard, number of levels used to report students' performance, student performance standards, and school performance standards. The second sub-score includes four variables: type of items contained in the student assessment, type of Assessment Used Statewide, scope of assessment, and teacher involvement with assessment. The third sub-score includes three variables: assessment used for student accountability, state used positive student accountability measures, and assessment used for student promotion. The fourth sub-score includes three variables: assessment used for school accountability, state used positive school accountability, and assessment results used for instruction.

Table A2
Factor loadings for first five components

	Component				
Variable	1	2	3	4	5
Number of levels used to report students' performance	.9				
Student performance standards	.8		-.4		
Relation of assessment to content standards	.8				
School performance standards	.7		-.3		
Type of items contained in the student assessment	.6	-.4	.3		
Teacher involvement with assessment	.5		.5		-.4
Assessment results used for instruction	.4			.3	
Assessment used for student accountability		.6	.3		-.4
State used positive student accountability measures		.6	.5		
Assessment used for student promotion		.4			
Type of assessment used statewide	.3	-.5	.6		
Scope of assessment	.4		.4		.3
Assessment used for school accountability	.4			.7	
State used positive school accountability				.6	.5
Number of grades tested in grades 1–5		.4		-.4	.5

Table A3.
Factor loadings for rotated components

	Component				
Variable	1	2	3	4	5
Student performance standards	.9				
Number of levels used to report students' performance	.9				
Relation of assessment to content standards	.9				
School performance standards	.8				
Type of assessment used statewide		.8			
Type of items contained in the student assessment	.3	.7			-.3
Scope of assessment		.6			
Teacher involvement with assessment		.6	.4		
Assessment used for student accountability			.8		
State used positive student accountability measures			.7		.4
Assessment used for student promotion			.4		.4
State used positive school accountability				.8	
Assessment used for school accountability				.7	-.4
Assessment results used for instruction				.4	
Number of grades tested in grades 1-–5					.8

Rotation converged in 38 iterations.

States with more than one assessment

As noted on page 8 note 4, several states had more than one assessment, and we display the policy scores in Table A4 below since they are excluded from the main analysis and Table 1.

Table A4.
States with more than one assessment

State	Assessment program	Policy score
ND	TerraNova (CTBS/5) Test of Cognitive Skills, Second edition (TCS/2)	3.1
AK	Norm-Referenced Testing (CAT/5)	-3.2
LA	The Iowa Tests, Complete Battery	-10.0
VA	Virginia State Assessment NRT Program	-15.1
AZ	NRT: Stanford Achievement Test, Ninth Edition	-17.2
WV	Writing Assessment	-17.9
WV	National Assessment of Educational Progress (NAEP)	-19.7

Note. The sum of the scores in this table plus the scores in Table 1 together have a mean of zero and standard deviation of one.

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