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# Teacher Education, Experience, and the Practice of Aligned Instruction

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## Abstract

Research over the past two decades has shown the alignment of teachers' instruction with state standards is generally weak. Proposing that alignment is a useful measure of teachers' curricular knowledge (Shulman, 1986), this study uses a large database of teacher reports of their content coverage to understand the relationship of teacher educational and career experience variables with instructional alignment. The results of the fixed effects models indicate significant, positive associations, though they are generally modest in magnitude. Implications for research and policy are discussed.

## Keywords

educational policy, teacher characteristics, quantitative research

One of the central policy objectives of standards-based educational reform efforts is to drive teachers to improve their instruction through aligning it with challenging academic content standards (Smith & O'Day, 1990). This instructional alignment—the extent to which the content of teachers' instruction agrees with the content specifications defined in state content standards (Porter, 2002)—is intended to lead to improvements in students' opportunity to learn and, subsequently, their achievement.

Despite the centrality of alignment in the theories of action underlying standards-based reform, research over the past decade has shown that the typical alignment of teachers' instruction with state standards is weak to moderate (Polikoff, 2012a, 2012b; Porter, McMaken, Hwang, & Yang, 2011; Porter, Smithson, Blank, & Zeidner, 2007). Research also identifies a number of factors that are likely to contribute to teachers' low alignment. Among these are the poor coherence of standards-based policy systems (Polikoff, Porter, & Smithson, 2011), the difficulty teachers and district leaders encounter in understanding the standards documents' content messages (Hill, 2001; Spillane, 2004), and the multiple layers of overlapping school, district, state, and federal policies (Wong, Anagnostopoulos, Rutledge, & Edwards, 2003). As the creation and promulgation of the Common Core State Standards suggests aligned instruction remains a key policy goal, more needs to be done to improve alignment.

Alignment is not low for all teachers, however. Alignment indices tend to be normally distributed, indicating some teachers are doing a better job of tying their instruction to the intended instructional targets (Polikoff, 2012a; Porter et al., 2007). One potentially fruitful avenue of helping teachers improve their instructional alignment, therefore, is in developing an understanding of the measurable teacher factors that

are associated with teachers' instructional alignment. If researchers and policy makers had a better understanding of which teachers are more and less likely to practice aligned instruction, it could help target preservice teacher learning experiences, professional development opportunities, and interventions designed to help teachers implement the Common Core and other state and national standards in the classroom with fidelity.

One important potential source of variation in teachers' alignment is teachers' educational and career experiences. Indeed, teachers' preservice education can influence teachers' understanding of standards (e.g., Anderson & Stillman, 2013; Frykholm, 1999), though empirical research on subsequent effects on standards implementation is limited. Drawing on the concept of “curricular knowledge” (Shulman, 1986, 1987), this study seeks to understand the ways in which teacher education and career experience are associated with the practice of aligned instruction. Specifically, this study uses survey data from more than 21,000 mathematics, English language arts (ELA), and science teachers in 31 states to investigate the following research questions:

*Research Question 1:* To what extent are measurable characteristics of teachers' education and career experience related to teachers' implementation of standards-aligned instruction?

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*Research Question 2:* To what extent do the relationships of education and career experience with aligned instruction vary across academic subjects and grades?

The results suggest several measurable characteristics of teachers' educational and career experiences are positively associated with alignment, including their years of experience, field of undergraduate or graduate study, and coursework. In addition, there is suggestive evidence that the associations of teacher characteristics with alignment differ for elementary and secondary teachers. Overall, however, the magnitude of the identified associations is fairly small, suggesting weak effects of teacher education as measured here on teachers' curricular knowledge.

## Background

### *The Importance of Alignment*

Given the definition of alignment offered above, I argue that instructional alignment is synonymous with the implementation of standards in the classroom. The alignment of instruction with state content standards is an essential goal of current standards-based reform policy. The original ideas underlying current policy argued that curriculum frameworks should "make public a common, challenging set of expectations for what all children should know and be able to do" (O'Day & Smith, 1993, p. 267). The standards were to specify the instructional target for teachers to focus on in aligning their instruction. The No Child Left Behind Act amplifies this goal, seeking alignment of assessments, curriculum materials, and instruction with state content standards. These mutually reinforcing sources are intended to provide teachers with clear, coherent messages about the most important content to teach. It is therefore an explicit intention of standards-based reform policy to increase alignment by creating coherent policy systems starting with content standards.

### *Existing Research on Alignment*

Dozens of survey studies conducted over the last two decades indicate that teachers are making great efforts to increase the alignment of their instruction with state standards (e.g., Hamilton & Berends, 2006; Koretz, Barron, Mitchell, & Stecher, 1996; Pedulla et al., 2003). However, much of the existing research on instructional alignment is methodologically limited (Polikoff, 2012a). For instance, many of the surveys used in the extant research on alignment rely on teacher reports of instructional change (e.g., Hamilton & Berends, 2006). Research indicates that survey questions of instructional change are more challenging for teachers than questions about instructional practices during a particular time period (Desimone, Le Floch, Ansell, & Taylor, 2005).

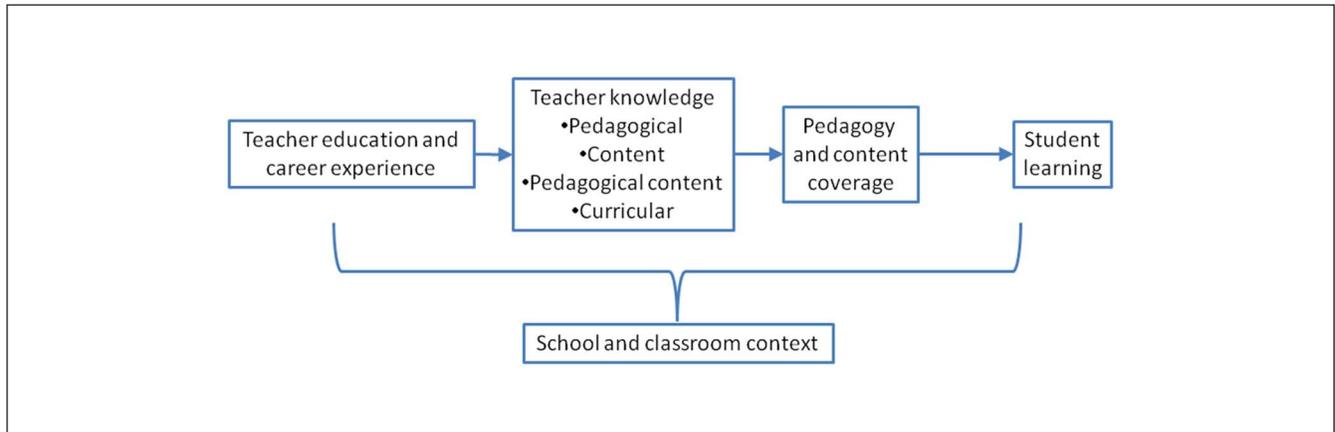
Survey questions about change in alignment are especially likely to elicit theory-driven reconstructions (Ross, 1989; Ross & Conway, 1986; Schwarz & Oyserman, 2001), with teachers perhaps reporting inflated efforts at alignment because alignment is a well-known intended outcome of standards-based reform policy. Another type of question used to gauge alignment is one that simply asks teachers about the alignment of their instruction or the alignment of district materials with standards or assessments (e.g., Pedulla et al., 2003). These questions are problematic because they rely on the assumption that teachers have common understandings of "alignment" and can accurately report on it. Finally, a third type of question used to gauge alignment asks teachers about changes in their instruction in tested and untested areas (e.g., Koretz et al., 1996), but these questions are at such a large grain size (e.g., "writing for a variety of purposes") that increased agreement may or may not correspond to meaningful increases in alignment. None of the above-mentioned alignment studies allow for examinations of the magnitude of alignment—rather they rely on Likert-type scale responses that are turned into proportions.

A stronger approach, one used in several recent analyses, is to use teacher self-reports of the content of their instruction during a school year and directly compare these with content analyses of state standards to estimate alignment (Polikoff, 2012a, 2012b). The alignment indices resulting from this technique have been shown to have positive correlations with student achievement gains in mathematics, further supporting the validity of this method of alignment research (Gamoran, Porter, Smithson, & White, 1997).

Two recent studies that use these more sophisticated alignment methods provide important information to motivate the current study. Notably, both studies find alignment tends to be low (less than 0.50 on the 0-1 scale) with few exceptions (Polikoff, 2012a, 2012b). Both studies also find that alignment indices are roughly normally distributed, with alignment slightly greater in ELA than in science or mathematics. Finally, these studies indicate there are several classroom variables that are statistically significant predictors of instructional alignment—including class size, student racial composition, and classroom average achievement.

### *Curricular Knowledge and Instructional Alignment*

The conceptual framework guiding the study is based on Shulman's (1986) notion of curricular knowledge (see simplified model in Figure 1). The development of teacher knowledge is "among the central questions for disciplined inquiry into teacher education" (Shulman, 1986, p. 9). Indeed, understanding the influence of teachers' pre- and inservice educational experiences on teacher knowledge and subsequent practice is a primary focus of teacher education research and practice (e.g., Darling-Hammond, 2000; Grossman, 1990; Putnam & Borko, 2000; Wilson & Floden, 2003).



**Figure 1.** Simplified conceptual model for the study of teacher effects on instruction and student outcomes

The simplified model in Figure 1 is based on Shulman's influential framework for teacher knowledge and suggests that teacher pre- and inservice education and career experience should influence teachers' instruction and student outcomes through the development of teacher knowledge. Shulman's framework categorizes teacher knowledge into three types: content knowledge, pedagogical content knowledge, and curricular knowledge. Although pedagogical content knowledge is concerned with subject matter knowledge for teaching, Shulman defined curricular knowledge as teachers' knowledge of

the full range of programs . . . the variety of instructional materials . . . and the set of characteristics that serve as both the indications and contraindications for the use of particular curriculum or program materials in particular circumstances. (Shulman, 1986, p. 10)

He argued that teacher preparation programs at the time were doing a poor job teaching pedagogical content knowledge to prospective teachers and an even worse job helping teachers understand and make use of resources to select and deliver content in the classroom.

Since Shulman's seminal piece, the concept of pedagogical content knowledge has become prominent in educational research. In contrast, curricular knowledge has been studied much less regularly; indeed, an ERIC keyword search of the phrase "pedagogical content knowledge" returns 1,206 peer-reviewed items since 1986, compared with just 15 for "curricular knowledge." This general trend is also true in the teacher education field. For instance, ERIC indicates there have been 32 articles published in the *Journal of Teacher Education* with "pedagogical content knowledge" as a keyword, as compared with 0 for "curricular knowledge." In some cases, curricular knowledge has been taken to be a subset of pedagogical content knowledge (e.g., Ball, Thames, & Phelps, 2008; Grossman, 1990, 1991). However, they were created as conceptually distinct concepts (Shulman, 1986),

and this article is among the first to focus on curricular knowledge independent of pedagogical content knowledge as it relates to knowledge development during teacher education.

In the standards-based education era, a teacher's curricular knowledge is perhaps best captured by the teacher's enactment of a standards-aligned curriculum. Nearly all teachers indicate in surveys that instructional alignment is an important goal that they are making efforts to meet (Hamilton & Berends, 2006; Koretz et al., 1996; Pedulla et al., 2003). Yet, the actual alignment of instruction with standards remains low (Polikoff, 2012a, 2012b). This discrepancy is likely attributable in part to the differential capacity of teachers to align their instruction, some of which is undoubtedly due to variation in curricular knowledge. There are many steps in between the desire of teachers to align their instruction and the actual alignment. First, teachers must understand the content messages of the standards, which may prove quite challenging (e.g., Hill, 2001). Teachers must then take that understanding and identify curriculum sources to cover those content messages. Finally, teachers must implement an aligned curriculum based on those sources. To be sure, teachers' implementation of an aligned curriculum is undoubtedly constrained by the resources available in her school or district. However, controlling for those resources, instructional alignment is an appropriate and important measure of the curricular knowledge of teachers.

### *Teacher Education and Career Experiences and Curricular Knowledge*

Although the literature on teacher knowledge development in general is extensive, the specific literature on the antecedents to teachers' curricular knowledge is weak (Davis, Petish, & Smithey, 2006; Deng, 2007). The limited research evidence suggests that teachers' preservice education, experience, and prior beliefs affect the development of curricular knowledge. Beginning teachers attribute much of their skill in selecting

and organizing content to their preservice education, particularly their content-area coursework (Adams & Krockover, 1997). Beginning teachers also tend to focus less on using their curricular knowledge to construct learning experiences in their 1st year, with these curricular knowledge skills developing in subsequent years (Friedrichsen et al., 2009). A number of authors argue that teacher beliefs have substantial impacts on their curricular knowledge and subsequent curriculum implementation (Elbaz, 1991; Ennis, 1994; Remillard, 2005), and that these beliefs are shaped by teachers' preservice and early professional experiences (Rovegno, 1993).

The literature also suggests that teachers' curricular knowledge is substantially mediated by local contexts. For instance, the extent to which a teacher can implement a high-quality English curriculum is contingent on the students' abilities and prior experiences, as well as the texts available for use in the classroom (Elbaz, 1991; Grossman, 1990, 1991). Furthermore, many teacher education researchers argue that teachers' implementation of standards should be contextualized in the school setting (e.g., Anderson & Stillman, 2013), implying that "perfect" implementation of standards may look different from school to school and classroom to classroom. Thus, studies seeking to relate teacher education and career experience to curricular knowledge must be sure to control for classroom contextual variables.

Given the literature on teacher education, career experience, and curricular knowledge, it is reasonable to expect that measurable indicators of teacher preservice education will be associated with teachers' implementation of standards-aligned instruction. It is not clear what direction or magnitude those associations should take, given the paucity of available literature. However, teachers presumably learn about standards and alignment in their teacher education programs, and this learning should translate into increased curricular knowledge. Furthermore, given the nonrandom sorting of teachers across schools, the relationship between teacher characteristics and alignment should be weaker when controlling for contextual features of the classroom. There is no evidence to support a hypothesis for or against the expectation that the association of teacher characteristics with alignment will differ by academic subject or grade, given the weak literature base.

There are several features that are notably lacking in the literature on teachers' curricular knowledge and its correlates. One is a high-quality, well-defined outcome measure for curricular knowledge. I propose that instructional alignment should be such a measure, as it incorporates the teacher's ability to draw upon curriculum materials and construct a sequence of learning experiences for students who match the expectations of state and district leaders. Another gap in the literature is a large-sample examination that incorporates teachers from across the country and in multiple contexts, which would give a more generalizable picture of curricular knowledge. Finally, a third gap is a systematic quantitative analysis that allows for the estimation of effect sizes in

interpretable scales and with understandable meanings. The work described here is an attempt to address these shortcomings in the literature and move to a measurable, generalizable understanding of the ways that teachers' educational and career experiences influence their reported enactment of curricula aligned with state standards.

## Data

The source of all teacher instructional data is a database of teacher surveys based on the Surveys of Enacted Curriculum (SEC) in mathematics, ELA, and science (Porter, 2002). Since the 2002-2003 school year, more than 40,000 SEC surveys have been completed by k-12 teachers for use in research studies or by districts or schools for the purpose of examining the enacted curriculum. The full database was used for this research. Teachers were included in the analytic sample if they taught in states and grades for which there was also content analysis data on the target content standards that were in place in the year the survey was completed. In the analytic sample for mathematics, there were 11,305 teachers from 26 states, 1,263 districts, and 2,679 schools. The numbers for ELA were 11,940 teachers from 19 states, 395 districts, and 949 schools. For science, there were 5,524 teachers from 22 states, 707 districts, and 1,402 schools. Not all of these teachers ended up in the final analytic sample due to missing data or if they were the only teacher in a particular grade/subject in their school.

The SEC is a well-studied instrument that has been used in its present form in dozens of research studies since 2002. It is based on nearly three decades' research, originating with efforts by researchers at Michigan State University's Institute for Research on Teaching to understand teachers' content decisions in elementary school mathematics (for more information on the history of the SEC, see Porter, 2002; Porter, Floden, Freeman, Schmidt, & Schwillie, 1988; Porter, Kirst, Osthoff, Smithson, & Schneider, 1993). The surveys are publicly available online at <http://seconline.wceruw.org/secWebHome.htm>.

The current form of the SEC has two parts. Part A is a survey of teachers' personal backgrounds, classroom contexts (e.g., student composition), instructional strategies, and professional development experiences. In Part B, teachers report the content they taught during the previous year. For this content taxonomy, teachers first identify from a list of 133 to 211 topics, depending on academic subject, all the topics they taught in the previous academic year in a target class. For each topic taught, they indicate the number of lessons on a scale of *no lessons*, *less than one lesson*, *one to five lessons*, and *more than five lessons*. They then allot the instructional emphasis for each topic among five levels of cognitive demand; the cognitive demand levels are listed and defined in the surveys. The year's instruction is turned into a matrix of proportions, with each proportion indicating the percent of the year's instruction dedicated to each topic-by-cognitive demand combination (in

Instruction	Cognitive Demand A	Cognitive Demand B
Topic 1	.10	.40
Topic 2	.50	0
Standards	Cognitive Demand A	Cognitive Demand B
Topic 1	.30	.10
Topic 2	.10	.50

**Figure 2.** Sample instructional and standards data for the calculation of alignment

SEC language, a “cell”). It is often the case that teachers will fill out the SEC in the winter and again in the spring, on each survey reporting only the content they taught in that period. Some teachers will also have been surveyed more than twice a year (e.g., for quarters), and others will have been surveyed just once. No matter the survey frequency, the results are aggregated to represent a full year by weighting each survey by the number of days it represents.

Teacher data from the SEC Part B can be compared with content analyses of state standards. Comparisons of instruction with the content of standards are for the purpose of calculating instructional alignment, described in more detail below. The content analysis procedures are as follows (Porter, 2002; Porter, Polikoff, Zeidner, & Smithson, 2008). Content analysts are trained subject matter experts. They analyze standards documents at the finest-grained level of detail possible (these are usually called objectives). Working independently, content analysts examine each objective and place it into between one and six cells in the SEC framework. Multiple cells are allowed because objectives often tap multiple topics and/or cognitive demand levels—in the case of multiple cells, the weight of the objective is evenly divided among the target cells. Each objective is weighted evenly because there is generally no indication in standards documents as to the relative importance of one objective versus another. Thus, the most replicable and defensible approach is equal weighting. After each rater has analyzed each objective, the ratings are converted into proportions indicating the percent of the total standards content in each SEC cell. These proportions are then averaged across raters, to arrive at the final content analysis. Data from the content analyses have been used for several studies of the content of state standards and assessments (Polikoff et al., 2011; Porter, 2002; Porter et al., 2011; Porter, Polikoff, & Smithson, 2009). Generalizability theory studies indicate that the content analyses are reliable (generalizability coefficients greater than .75) with three to four raters (Porter, 2002; Porter et al., 2008), and all content analyses used here had at least that many raters.

Existing research lends support to the instructional measures derived from the SEC Part B. Research conducted during the development of the instrument indicated that teachers were comfortable making distinctions at the fine-grained

level of topic-by-cognitive demand, that teacher ratings of content coverage of individual lessons correlated moderately with ratings by external observers, and that teacher reports of content coverage over a semester or year correlated highly with aggregated daily logs (Porter et al., 1993). Furthermore, one study of instructional alignment based on the SEC found significant correlations with value-added to student achievement ( $r = .45$ ; Gamoran et al., 1997), and a recent study found that the correlations of instructional alignment with value-added were as strong or stronger than the correlations of pedagogical quality measures derived from established observational protocols with those same value-added measures (Polikoff, 2012c). Together, these studies suggest that the SEC surveys indeed measure important elements of teachers’ content coverage. Compared with other methods of measuring the content of instruction over a full year and estimating alignment, the SEC has the most validity and reliability evidence to support it.

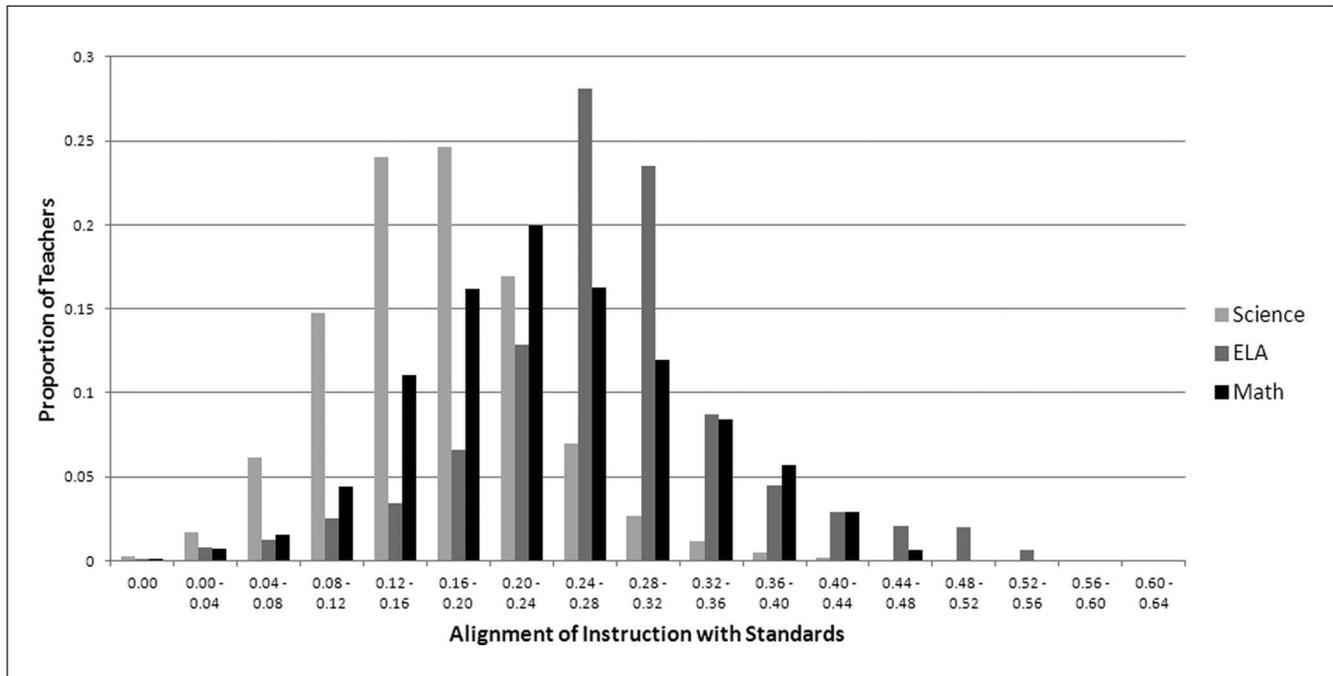
### Dependent Variable

The dependent variable for this investigation is an index of teachers’ instructional alignment with state content standards. Alignment is calculated by comparing the matrix representing teachers’ instruction with the matrix representing the content of standards. The formula for alignment (Polikoff, 2012a; Porter, 2002) is as follows:

$$\text{Alignment} = 1 - (\sum_i |x_i - y_i|) / 2 \quad (1)$$

Here,  $x_i$  and  $y_i$  represent the proportion of content in cell  $i$  of document  $x$  and document  $y$ , respectively. Mathematically, this formula is equivalent to the sum of the cell-by-cell minima.

Alignment ranges from 0 to 1 and indicates the proportion of content in exact agreement at the cell level. For example, consider the two matrices in Figure 2. The top matrix represents a teacher’s reported instruction, and the bottom matrix represents the content analysis of the standards. Here, the alignment is .30, which can be seen by applying the formula or taking the sum of the cell-by-cell minima (.10 for each of cells A1, A2, and B1, 0 for cell B2). This indicates that 30% of the content of teacher’s instruction is in exact proportional agreement at the cell level with the content analysis of the standards (and also that 30% of the content in the standards is in exact proportional agreement at the cell level as the teacher’s reported instruction). Previous results indicate that alignment indices for the alignment of instruction with standards or assessments are normally distributed with means below 0.50 (Polikoff, 2012a; Porter et al., 2007). For the purposes of these analyses, alignment with standards was calculated for any teacher in a state, grade, subject, and year for which there was also a content-analyzed set of standards available.



**Figure 3.** Frequency distribution of alignment indices for the three content areas

The average alignment indices indicate low agreement between instruction and the target (standards or assessments) across all subjects. Average alignments are in the 0.17 to 0.27 range, with the highest average alignments for ELA and the lowest for science. No alignment index for any teacher in the database is above 0.63. Figure 3 shows a frequency distribution for the alignment indices for the three subjects. The alignment indices are close to a normal distribution for each subject and overall, with the means highest in ELA and lowest in science.

### Independent Variables

The focal independent variables for this analysis are a set of teacher-reported measurable education, credential, and career experience indicators drawn from the SEC Part A. Classroom control variables drawn from the SEC are also included.

**Teacher Characteristics.** Several descriptive characteristics of teachers' education and career experiences were reported in the SEC Part A. Descriptive statistics for these and all other independent variables are reported in Table 1. The teacher characteristics include the following:

- Master's—an indicator for whether the teacher has received a master's degree;
- Content degree—an indicator for whether the teacher received either a master's or bachelor's degree in the target content area;
- Content/education degree—an indicator for whether the teacher received either a master's or bachelor's degree in the content area and education (e.g., mathematics education), and did not also receive a degree in the content area only. Therefore, the reference category for content degree and content/education degree is the set of teachers who received neither a bachelor's nor a master's degree in the content area for which they completed the SEC, nor the content area/education;
- Experience—on a scale of less than 1 year, 1-2, 3-5, 6-8, 9-11, 12-15, and more than 15 years. Due to recent research suggesting that teacher experience is best treated nonparametrically (Papay & Kraft, 2010; Wiswall, 2011), the experience variable is turned into a set of six dichotomous variables, with less than 1 year experience being the reference category;
- Content courses—the teacher's reported total number of university-level quarter- or semester-long courses in content. In mathematics, these are refresher mathematics courses (e.g., algebra, geometry) and advanced mathematics courses (e.g., calculus, statistics). In ELA, these are English/American literature and writing, composition, speech, and theater. In science, these are biology/life science, physics/chemistry/physical science, and geology/astronomy/earth science;
- Content/education courses—the teacher's reported number of university-level quarter- or semester-long courses on content-area-specific education

**Table 1.** Sample Descriptive Statistics

Variable	Mathematics		ELA		Science		All	
	M	SD	M	SD	M	SD	M	SD
<b>Classroom variables</b>								
Class size	21.46	6.34	19.42	6.38	23.04	6.15	20.90	6.47
Percent White students	66.31	31.77	55.40	36.52	63.43	34.17	61.22	34.64
Percent English language learners	5.64	13.34	6.28	15.37	6.64	14.61	6.09	14.46
High achievement	0.07		0.04		0.07		0.06	
Average achievement	0.35		0.26		0.39		0.32	
Low achievement	0.21		0.30		0.17		0.24	
Tracking	0.35		0.33		0.17		0.31	
<b>Teacher variables</b>								
Years experience	9.31	6.29	10.29	6.19	8.28	6.19	9.52	6.27
Master's degree	0.50		0.60		0.44		0.53	
Content degree	0.18		0.25		0.27		0.22	
Content/education degree	0.07		0.40		0.28		0.25	
Content courses	3.24	3.29	7.17	4.17	7.41	5.70	5.68	4.64
Content/education courses	2.17	2.06	3.56	2.44	2.28	2.18	2.78	2.35
Certification	0.71		0.75		0.69		0.72	
Year = 2003	0.01		0.00		0.02		0.01	
Year = 2004	0.04		0.07		0.05		0.06	
Year = 2005	0.12		0.13		0.19		0.14	
Year = 2006	0.18		0.21		0.20		0.10	
Year = 2007	0.22		0.28		0.20		0.24	
Year = 2008	0.23		0.22		0.23		0.22	
Year = 2009	0.10		0.08		0.11		0.09	
Year = 2010	0.11		0.00		0.00		0.04	
<b>Outcome</b>								
Alignment with standards	0.24	0.08	0.27	0.09	0.17	0.07	0.24	0.09

Note: ELA = English language arts.

(i.e., mathematics education; teaching of English, language arts, or reading; science education);

- Certification—a dichotomous variable indicating the teacher's certification aligns with the teaching assignment for the target class.

**Classroom Controls.** To control for sample composition and isolate the unique effects of teacher education and career experience variables, a set of classroom controls are used, which are derived from the SEC Part A and refer only to the target class for which alignment was calculated. These are class size, percent White students, percent English-language learners (ELLs), and dichotomous variables for tracking, high, medium, and low achievement levels. Class size is the number of students in the class, on a scale of 10 or fewer, 11-15, 16-20, 21-25, 26-30, 31, or more. Percent White students is on a scale of less than 10%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, or more. Percent ELL is on a scale of none, less than 10%, 10%-25%, 26%-50%, and more than 50%. Each of these was rescaled to the median interval value for each scale point (with the top and bottom class sizes rescaled to 33 and 8, respectively).

Tracking is a dichotomous variable indicating the primary factor in scheduling students into the target class is ability/prior achievement. High, medium, and low achievement are dichotomous variables indicating the teacher-reported ability level of most of the students in the class compared with national norms, with the reference group being mixed ability levels. Unfortunately, the data do not contain classroom controls for student poverty. Nonetheless, school-mean differences in poverty would be accounted for by the fixed effects modeling strategy discussed below.

Descriptive statistics in Table 1 highlight that 53% of surveyed teachers have a master's degree and 47% have a content or content/education degree. The average teacher indicates having taken approximately six content courses and three content/education courses. There are large variations across subjects, however. In particular, mathematics teachers are far less likely than ELA or science teachers to have a content or content/education degree, at just 25% (as compared with 65% and 55%, respectively). Mathematics teachers also have the least content and content/education coursework. The ELA teacher sample is mostly elementary school teachers (85%), whereas the mathematics (60%) and

science (53%) samples are more evenly split. Approximately 70% of the sample was collected between 2005 and 2008.

## Method

Given the nature of the data—a convenience sample of teachers from across states, grades, and schools spread across three subjects—the most appropriate modeling strategy is to use fixed effects to control for variations in sample composition. A conservative approach is to include fixed effects for each combination of school and standards document. A fixed effect for each school/standards combination accounts for observed and unobserved differences among schools and standards documents, such as the fact that some standards documents are more prone to high alignment (Polikoff, 2012b) and the fact that some schools are likely to provide teachers with better-aligned curriculum materials than others. Thus, the fixed effects regressions are focused on explaining the variation in aligned instruction among teachers who teach to particular sets of content standards in particular schools (e.g., the variation in alignment among fourth-grade mathematics teachers at Johnson Elementary but not the variation between these teachers and fifth-grade mathematics teachers at Johnson Elementary, fourth-grade ELA teachers at Johnson Elementary, or fourth-grade mathematics teachers at any other school). The school/standards fixed effects also account for unobserved features of districts or states (in which schools are nested). The model used in the main analysis is therefore as follows:

$$Y_{ijs} = \sum_{k=1}^{19} \beta_k T_{kij} + \sum_{k=20}^{26} \beta_k C_{kij} + \rho_{js} + \varepsilon_{ijs},$$

where  $Y_{ijs}$  is a measure of the instruction provided by teacher  $i$  in school  $j$  teaching to standards document  $s$ . On the right side of the equation,  $T_{kij}$  and  $C_{kij}$  are vectors of teacher and classroom characteristics, respectively; these are entered in blocks. Included in the teacher variables are a set of dummy variables, one for each year (with 2007 as the reference category). These control for secular trends in alignment over time; the coefficients are not reported in the tables. Given the fixed effects and year dummies, the coefficients on the teacher and classroom variables are identified off variation among teachers within school/standards document combinations in particular years. For instance, these coefficients are based on comparisons of the alignment of 2 fourth-grade mathematics teachers' 2009 instruction in a given school with state standards, but not comparisons between fourth- and fifth-grade teachers, between fourth-grade math and fourth-grade science teachers, or between 2 fourth-grade mathematics teachers from different years.

Because of the inclusion of school/standards document fixed effects, the inclusion of school-level controls is not appropriate because these would be collinear with the fixed effects and would have little variation off which to identify

effects. The fixed effects for schools/standards documents are represented by  $\rho_{js}$ . For the analysis of interaction effects between teacher characteristics and subject area or grade, the teacher characteristics in the vector  $T_{kij}$  are interacted with dichotomous variables for mathematics and science or secondary grades (6-12).

To aid in interpretation, the outcome variable and all continuous variables are standardized, while dichotomous variables are kept as 0-1 variables. Thus, the coefficients on the continuous variables indicate the predicted difference in standard deviations of instructional alignment associated with a one standard deviation difference in the continuous independent variable. The coefficients on the dichotomous variables indicate the predicted difference in standard deviations of instructional alignment moving from 0 to 1 on the dichotomous variable (e.g., comparing a teacher who does not hold a master's degree with one who has such a degree). In all cases, standard errors are clustered to the state level. The results are essentially equivalent to hierarchical linear models, except the standard errors are larger in the fixed effects models than they are in the corresponding HLMs. All models were run in parallel using multilevel models (teachers nested in schools) and none of the substantive results were affected by model specification.

## Results

### *The Relationship of Teacher Characteristics With Alignment*

The main regression results are presented in Table 2, with the variables entered in blocks. The first set of results shows the results from a naïve regression with no fixed effects. These results are presented to show the importance of capturing unobserved features of schools and standards documents with fixed effects. While all but two of the teacher variables are significant predictors of alignment, the model explains just 7% of the variation in instructional alignment. The results suggest that teachers with more than 1 year of experience (except for those with 12-15 years of experience) would outperform teachers with less than 1 year of experience (the reference category). The results also suggest substantial positive associations of master's degrees, certification, and content/education courses and degrees with alignment. Finally, the results indicate that teachers with content-area degrees and more content-area coursework would be associated with reduced alignment as compared with teachers without such degrees and with fewer content courses, though the coefficient on degrees is not statistically significant.

The second set of results merely adds the fixed effects for schools/standards documents, as described in the main model. In addition to the substantial boost in explanatory power resulting from the fixed effects, several of the main results change substantially in this model. Together, these

**Table 2.** Regression Results Predicting the Alignment of Teacher-Reported Instruction With State Standards

Variable	No fixed effects		Fixed effects, no controls		Full model		Outlier teachers removed	
	$\beta$	<i>t</i>	$\beta$	<i>t</i>	$\beta$	<i>t</i>	$\beta$	<i>t</i>
Classroom variables								
Class size					.07*	5.69	.07*	5.98
Percent White students					-.02*	-2.30	-.02*	-2.22
Percent English language learners					-.02*	-2.49	-.02*	-2.65
High achievement					-.02	-0.48	-.02	-0.55
Average achievement					-.03	-1.87	-.02	-1.81
Low achievement					-.10*	-2.88	-.10*	-2.91
Tracking					-.08*	-4.10	-.08*	-4.15
Teacher variables								
1-2 years experience	.11*	3.74	.07*	1.98	.07*	2.24	.07*	2.26
3-5 years experience	.09*	3.37	.05*	2.22	.05	1.95	.05	1.93
6-8 years experience	.13*	4.64	.10*	2.65	.09*	2.25	.09*	2.21
9-11 years experience	.11*	3.59	.09*	3.89	.08*	2.99	.08*	2.79
12-15 years experience	.06	1.93	.06	1.89	.04	1.20	.04	1.17
15+ years experience	.06*	2.57	.05*	2.10	.05	1.61	.04	1.60
Master's degree	.23*	16.65	-.02	-0.96	-.01	-0.88	-.01	-0.88
Content degree	-.03	-1.61	.01	0.35	.01	0.28	.00	0.26
Content/education degree	.08*	5.13	.04*	2.15	.03	1.76	.03	1.77
Content courses	-.07*	-8.33	.02*	2.82	.02*	2.26	.02*	2.25
Content/education courses	.16*	18.60	.00	0.33	.00	0.09	.00	0.14
Certification	.13*	8.22	.06*	2.19	.05	1.80	.05	1.79
<i>n</i>	21,812		21,812		21,721		21,592	
<i>R</i> <sup>2</sup>	.07		.73		.74		.74	

Note: Continuous variables and dependent variable are standardized, dichotomous variables are not. All models include year dummies; coefficients not shown. \* $p < .05$ .

changes indicate the importance of controlling for sample composition (states, grades, subjects, and schools). For example, with the exception of the coefficients on the experience indicators for highly experienced teachers, the coefficients on the other teacher characteristic variables are closer to zero in the fixed effects models. Among teachers in particular schools who all teach to a particular set of standards, experience remains positively associated with alignment. However, the relationship appears nonlinear, with a sharp increase from less than 1 to 1-2 years ( $b = .07$ ,  $p = .05$ ), a peak at 6-8 years ( $b = .10$ ,  $p < .01$ ), and a decrease thereafter. There is also a positive association of content-area coursework ( $b = .02$ ,  $p < .01$ ), content/education degrees ( $b = .04$ ,  $p < .05$ ), and correct certification ( $b = .06$ ,  $p = .04$ ) with alignment. In contrast, the inclusion of the fixed effects reduces to statistical insignificance the relationship between master's degrees and content/education courses with alignment.

The full model, shown in the next set of columns, includes the additional classroom characteristics. The results of this model support the conclusion that contextual factors are associated with teachers' implementation of aligned curricula; however, the contextual factors uniquely explain a small proportion of the variation in alignment. For instance, instructional

alignment is lower in classes where average achievement is low ( $b = -.10$ ,  $p < .01$ ), in classes that are tracked ( $b = -.08$ ,  $p < .01$ ), in classes with a higher proportion of ELL ( $b = -.02$ ,  $p = .02$ ), and in classes with a higher proportion of White students ( $b = -.02$ ,  $p = .03$ ). In contrast, alignment appears greater in classes that are larger ( $b = .07$ ,  $p < .001$ ).

In general, the addition of contextual variables does not markedly change the coefficients on the teacher characteristics, compared with the model that did not include context. Although four of the coefficients moved to statistical insignificance after controlling for contextual effects, the magnitudes of the coefficients decreased no more than .02 for any variable. There are still significant associations of teacher experience (1-2, 6-8, and 9-11 years, as compared with less than 1 year) and content-area coursework with instructional alignment.

Overall, the results of the main models suggest instructional alignment is significantly related to several measurable characteristics of teachers, including their experience and the number of content courses they have taken. Summing across the significant predictors in the full model, a teacher with 6 to 8 years of experience who was one standard deviation above the mean in content-area courses (10.3 as compared with 5.7) would be expected to practice 0.11 standard deviations more

**Table 3.** Exploratory Regression Results for Interaction Effects With Teacher Characteristics

Main effects (ELA)			Math interactions		Science interactions	
Variable	$\beta$	$t$	$\beta$	$t$	$\beta$	$t$
1-2 years experience	.09	1.32	-.01	-0.18	-.07	-0.97
3-5 years experience	.06	1.02	.00	-0.08	-.04	-0.47
6-8 years experience	.10	1.50	-.01	-0.22	-.07	-0.86
9-11 years experience	.09	1.84	-.02	-0.46	-.01	-0.12
12-15 years experience	.03	0.57	.06	1.13	-.03	-0.48
15+ years experience	.06	1.25	-.02	-0.59	-.03	-0.72
Master's degree	-.03	-0.86	.04	1.30	-.01	-0.18
Content degree	.01	0.65	-.01	-0.32	-.01	-0.19
Content/education degree	.02	1.89	.05	0.93	.00	0.02
Content courses	.04	1.84	-.06	-1.88	-.03	-0.71
Content/education courses	-.02*	-2.88	.06*	3.20	.04	1.67
Certification	.01	0.25	.06	1.46	.12*	4.85

Main effects (elementary)			Secondary interactions	
Variable	$\beta$	$t$	$\beta$	$t$
1-2 years experience	.05	1.14	.03	0.41
3-5 years experience	.01	0.23	.08	1.31
6-8 years experience	.06	1.09	.04	0.58
9-11 years experience	.03	1.03	.09	1.69
12-15 years experience	.00	0.06	.08	1.66
15+ years experience	-.01	-0.39	.12*	4.14
Master's degree	.00	-0.24	-.02	-1.00
Content degree	-.01	-1.36	.04	1.80
Content/education degree	.02*	2.23	.01	0.19
Content courses	.02*	2.44	.01	0.27
Content/education courses	-.02	-1.53	.04*	2.26
Certification	.04*	2.72	.02	0.78

Note: ELA = English language arts. Results based on main regression models. Coefficients for classroom characteristics not shown for space. All models include year dummies; coefficients not shown.

\* $p < .05$ .

aligned instruction than an otherwise comparable teacher with no experience and an average number of content courses. The effects are not large, but they are consistent even when looking within individual schools, grades, and subjects.

### Interactions With Academic Subject and Grade

The second research question asks the extent to which the main results vary across academic subjects and grade levels. For academic subjects, the main model (including classroom controls and school/standards fixed effects) is used, with each teacher variable interacted with a dichotomous variable for mathematics and a separate dichotomous variable for science. The coefficients on the classroom controls are not shown due to space. This analysis is best treated as an exploratory investigation, given the paucity of existing research that compares effects across subjects. The results of the fixed effect regressions are shown in Table 3, with ELA as the reference category.

The top panel of Table 3 shows a consistent pattern of statistically insignificant interaction effects. There are also few significant main effects in the top panel of Table 3, owing to the reduced power for estimating these interaction effects. There are neither significant coefficients for mathematics nor science for the experience variables or any of the degree indicators or coursetaking variables, except for a significant positive relationship between content/education courses and instructional alignment for mathematics teachers (there is a significant and negative main effect for ELA teachers). There is also a significant positive association between proper certification and instructional alignment for science teachers, but there is no significant main effect for English teachers. Taken together, and considering the large number of hypothesis tests conducted, the results suggest that the associations of experience, degrees, and coursework with alignment are largely consistent across the three subjects. The possible exceptions are for content/education coursework and certification status, where the positive associations identified in the main analysis may be driven by

mathematics or science teachers. Again, these results should be treated as only exploratory.

For grades, teachers are grouped into elementary (k-5) and secondary (6-12). A dichotomous variable for secondary teachers is then interacted with each of the teacher educational and career experience variables. The results are shown in the lower panel of Table 3, with the main effects representing elementary teachers. These results show some evidence of interaction effects. Notably, the associations of experience with alignment may be driven by secondary teachers as compared with elementary teachers. None of the six dichotomous experience indicators is statistically significant for elementary teachers, and one is significant for secondary teachers. Other experience coefficients for secondary teachers are relatively large in magnitude but not significant. Furthermore, there is a positive and significant interaction of content/education courses for secondary teachers. In contrast, the associations of content/education degrees and content courses appear to be driven by elementary teachers. Overall, these results are suggestive that there are grade-level differences in the associations of teacher education and career experiences with alignment. Because the definition of elementary and secondary differs across states, several alternative criteria were attempted to define the elementary/secondary cutoff (e.g., k-4 and 5-12, k-6 and 7-12). In general, these alternative models did not change the substantive results just described, though the elementary/secondary difference was most pronounced when k-5 and 6-12 were used to define the two groups.

### Sensitivity

The main models for this analysis are conservative—They are only focused on exploring the variation among teachers within particular schools teaching to particular sets of standards. Thus, there should be little concern about omitted school-level variables, given that all time-invariant school characteristics are accounted for by the fixed effects. However, one potential validity concern with these analyses is that all of the instructional data are self-reported. Extant research (Mayer, 1999) indicates that the validity of teacher self-report depends on a number of factors. For instance, teachers are generally unable to accurately rate the quality of instruction they provide. Composite scales of instruction provide better data than individual indicators. Furthermore, teachers may not be good at indicating the amount of time they spend on various tasks. In contrast to Mayer's work, there is a good deal of validity and reliability evidence for the SEC (Porter, 2002; Porter et al., 1993; Porter et al., 2008), and this has been discussed above.

Even with a well-studied tool such as the SEC, there is the possibility that the instrument may capture instruction more or less accurately for different kinds of teachers. That is, it may be the case that some teachers in the sample completed the survey less accurately than others. In this case, removing

these teachers from the sample should improve the precision of the results. Although it is impossible to know how accurate each teacher was in completing the survey because there is no criterion measure, the SEC data can provide a clue. One potential indication that a teacher did not complete the instrument accurately is if she indicates covering an abnormal number of topics relative to the other teachers in the data.

To investigate this issue, teachers were classified using a raw count of the number of SEC cells the teacher indicated covering in the target class. Outliers were identified by examining boxplots and applying customary rules for outliers (i.e., more than 1.5 interquartile ranges outside the upper and lower quartiles). This technique removed 13 teachers in mathematics, none in ELA, and 123 in science. With these teachers removed from the data set, the main model was rerun; the results are presented in the last column of Table 2. Given the small number of teachers who appear to be outliers in their survey responses, it is not surprising that the results do not change from the main analyses. There is no evidence from these results that the main findings are attributable to poor quality survey data.

### Discussion

Given the importance of alignment in current standards-based reform policy systems, it is notable that so little high-quality research has focused on advancing our understanding of the antecedents of aligned instruction. For instance, although teacher education research focuses a great deal on teacher knowledge development (e.g., Darling-Hammond, 2000; Grossman, 1990; Putnam & Borko, 2000; Wilson & Floden, 2003), there is relatively less focus on knowledge of standards and standards implementation in that literature. Where standards implementation is a focus, there has never been a study with the large teacher sample and high-quality measure of alignment used here. The purpose of this investigation was to understand the relationships between measurable characteristics of teachers presumably associated with the development of their knowledge (i.e., their preservice education and years of experience) and the teacher-reported enactment of curricula aligned with mathematics, science, and ELA standards.

Fixed effects regressions using surveys from more than 21,000 teachers indicate that several measurable characteristics of teachers are related to alignment. Although most of the coefficients are modest in magnitude, they indicate more experienced teachers with more content-area coursework practice more aligned instruction. These effects appear constant across subjects, but they may differ by grade. When aggregated, the coefficients suggest that teachers with extra content-area coursework and several years experience would practice approximately 0.11 standard deviations more aligned instruction than brand-new teachers without those credentials. Extrapolating based on prior research on the relationship between alignment and student achievement

gains (Gamoran et al., 1997) suggests these differences could be associated with effects of roughly 0.06 standard deviations. If we were to add in the positive but nonsignificant coefficients on some of the other teacher predictors, these total predicted effects would be higher.

Together, the findings of this work support previous research identifying associations of teacher education and career experience with their curricular knowledge (Friedrichsen et al., 2009; Rovegno, 1993). The findings also support the conclusion that teachers' preservice education and career experiences enhance their subsequent classroom instruction (e.g., Darling-Hammond, 2000). Furthermore, these results are consistent with the research finding of increased student achievement over the first few years of teaching with diminished returns thereafter (e.g., Harris & Sass, 2011), though there are surely other plausible explanations for that finding as well.

Despite the consistency of the findings with prior research and with theory, the magnitude of the effects is unquestionably small. This is not totally surprising, given the generally weak direct effects of measurable teacher education and career experience variables on student achievement gains found throughout the literature (e.g., Harris & Sass, 2011; Jepsen, 2005; Nye, Konstantopoulos, & Hedges, 2004). However, it is nonetheless disappointing that teacher education and career experience variables do not seem to produce substantial gains in their curricular knowledge. It may certainly be the case that the primary drivers of teachers' instructional alignment are more proximal measures of their work environment and student populations, which would be contained in the school/standards fixed effects used here. On the other hand, it may be that curriculum materials are the most important influences on teachers' alignment. Finally, it may be that more precise measures of teachers' educational experiences would show stronger associations with aligned instruction. Each of these hypotheses merits further investigation.

There are several important limitations of the research. It would be useful to have more detailed measures of teachers' education and career experience, such as their transcripts, career trajectories, and professional development experiences. Such data would enable more precise estimates of the associations of particular features of teacher education and career experience with the outcome. It would also be useful to triangulate these findings, which are based on teacher self-report of instructional content, with results based on measures that do not rely on self-report. However, measuring the content of instruction through observational methods over a full year would be truly expensive and time-consuming, particularly for such a large sample as was used here. Furthermore, the validity evidence discussed above suggests the SEC can validly be used to measure alignment in a way that is predictive of achievement gains. Nonetheless, there is often rightful skepticism about teacher self-reported instruction. Finally, this study operationalized curricular knowledge

by instructional alignment, but there are surely other measures of curricular knowledge that are possible to conceive and measure. Thus, I have ignored the real possibility that more knowledgeable teachers might purposefully choose not to implement certain content in the standards, for instance, because they view the content as culturally inappropriate (e.g., Sleeter, 2005). Given the centrality of curricular knowledge in Shulman's (1986) conceptualization of teacher knowledge, it would be a great benefit to the field to have a robust debate as to the most appropriate measures of curricular knowledge and the place of curricular knowledge as a central goal of teacher education.

The results may have implications in teacher education research and practice. They suggest that aspects of teacher education and career experience are positively associated with teachers' curricular knowledge and standards implementation. Although not causal, the results are supported across several sets of fixed effects that eliminate variation due to standards documents and features of schools that may also be associated with alignment, as well as secular trends in alignment over time. Future research should probe more precisely on the specific ways that teacher education programs influence teachers' understanding and use of standards documents in diverse classrooms (Anderson & Stillman, 2013). For instance, research should focus on explaining the finding that content-area coursework is associated with more aligned instruction by studying the content of such coursework across settings and its relationship with knowledge growth. Standards-aligned instruction is clearly an important policy goal; thus, more high-quality research in the teacher education community should address the issue of teacher curricular knowledge development. Establishing collaborative research relationships that span fields such as teacher education, data use, and standards implementation may be an especially promising avenue for uncovering important findings.

The results also suggest that curricular alignment increases with experience to a point (approximately 8-11 years) and decreases thereafter, with brand-new teachers exhibiting the weakest alignment. It is unsurprising that alignment would not be a great focus in the 1st year in the classroom—research consistently demonstrates that curricular issues often take a back seat to more pressing issues such as classroom management (e.g., Feiman-Nemser, 2003). Thus, it is apparent that supporting beginning teachers to implement standards-aligned curricula might be a worthy programmatic goal for schools and districts. Supporting beginning teachers by providing them with clear, well-aligned curricula should improve their alignment and allow them to focus on other 1st-year challenges. As for the finding of decreased alignment after 11 years of experience, these are older teachers who entered the classroom before the mid-1990s. Thus, for these teachers, the use of content standards may have been less of a focus of their teacher education programs. On the other hand, it may be possible that these

teachers' experiences of educational change differ from those of their younger colleagues (Hargreaves, 2005). In either case, very experienced teachers may also need additional support for standards implementation from schools and districts.

As the Common Core Standards are implemented in the states, it is increasingly important to understand the ways education research and policy can help support their implementation. Together with other research (Polikoff, 2012b; Porter et al., 2011; Porter et al., 2007), this work points toward factors associated with improved alignment. However, a great deal more will need to be done if we are to develop a strong, research-based understanding of the ways to promote curricular knowledge and the adoption of standards. Preservice teacher education is not the only field that will need greater attention to standards implementation; work must expand in areas such as teacher professional development, curriculum policy, and accountability. Given that implementation of standards thus far has been weak (e.g., Polikoff, 2012a; Spillane, 2004), doing more of the same in policy and research is a strategy doomed to failure.

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