What the research here shows is that educational research presents a picture that discourages differentiation and experimentation.

Will Race to the Top Have the Same Mixed Results No Child Left Behind had on Student Learning and Preservice Teacher Preparation?

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Abstract

Race to the Top (RTTT) creates concerns for researchers and teachers (Owens, 2009) because of its emphasis on high-stakes testing and the continued lack of collaboration among educators, researchers, and policy makers. These laws reflect Foucault's notion of governmentality due to the approach taken to meet the aims of both the Bush and Obama administrations. This four-step study looked into the impact No Child Left Behind (NCLB) had on preservice teacher preparation based on the integrated math-science (IMS) model. A review of the literature identified 16 studies on IMS that provided the basis for a national survey to determine the reasons for offering IMS, the successes and challenges of the model, and the future of IMS at their higher education institutions (HEI). The number of IMS courses was lower than found in catalogs and the overall rate of IMS courses during 2004-05 was comparable to that in the 1950s.

Key Words

Governmentality, Integrated Math-Sciences, Preservice Teacher Preparation, Race to the Top, STEM

Race to the Top (RTTT), part of the *American Recovery and Reinvestment Act* of 2009 (ARRA), is in part an attempt to circumvent the perceived failings of No Child Left Behind (NCLB) (McGuinn, 2010). Its priorities have implications for STEM education at the P-20 and workforce level and, indirectly as a result of what states have to do to meet the priorities, also on preservice teacher preparation in teaching integrated math and science (IMS). Specifically, RTTT's Priority 2 requires states to emphasize STEM education, requiring a rigorous course of study in these areas. It also calls for establishing partnerships with STEM-capable community partners to prepare and assist teachers in integrating STEM content across grades and disciplines to promote relevant instruction and learning opportunities and providing advanced studies and careers in STEM, accentuating how to get more under-represented groups, women, and girls interested in STEM courses and careers (U.S. Department of Education, 2009). RTTT Priority 5 indicates that states have to address the alignment and coordination of the school-to-work pipeline (to borrow from a program from the Clinton Administration) "to ensure that students exiting one level are prepared for success, without remediation, in the next" (p. 5). Emphasis under this priority is in the transition points between educational levels (preschool to K-12, K-12 to college/university, college/university to work and career, or K-12 to work/career). It is also important that states provide high-need students with an array of opportunities and services they need to succeed even if these are beyond the capacity of a school itself to provide.

RTTT's approach of a competitive grant program to create systematic rather than targeted change in education embodies a change in strategy in fostering a national agenda (McGuinn, 2010). Even so, it reflects the Obama administration's ambivalence in crossing the line between federal mandates and state discretion in educational matters (McGuinn, 2012). Such a change in approach leads to the obvious questions of cost effectiveness (cf. Kolbe & Rice, 2012), effectiveness in creating change, and of improved student learning.

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While this last question may be unfair in regard to the ability to correctly anticipate or divine potential consequences, the history of change resulting from policy implementation (cf. Gillies, 2008) can identify potential areas of concern. This paper is an example of how an intended consequence from a systematic response to NCLB in the area of IMS education, particularly preservice teacher preparation of math and science teachers, did not come to pass.

Under NCLB, schools had to assess students in mathematics, reading/language arts, and science (Pilotin, 2010); however, state report cards reported on mathematics and reading arts. One consequence of the Academic Yearly Progress (AYP) report card's focus on reading/language arts and mathematics was that it led to a 32% average reduction in time for other subjects when compared to 2001-02 (McMurrer, 2007). According to the report from the Center on Education Policy (CEP), science, along with social studies, art and music, physical education, and time for lunch/recess were cut back about an average of 30 minutes per day. Districts with at least one school identified as in need for improvement were found to report at a higher rate a decrease in time devoted to teaching science, social studies, art and music. One recommendation CEP gave as a means to help remedy this decrease in coverage in these areas to accommodate increased instruction time in language arts and mathematics was for the federal government to fund "research to determine the best ways to incorporate the teaching of reading and math skills into social studies and science" (p. 2). Combine this recommendation with Czerniak, Weber, Sandmann, & Ahern's (1999) expressed need for more models of teacher preparation and greater preservice teacher familiarity with state and national reform recommendations, the focus of attention comes to two questions: Why did the integrated teaching of math and science not take hold? and Where have the political will and wise educational policies, to paraphrase Vars (2001), been to ensure that the teaching of science did not become a victim of policy steering defining education quality? It seems that Ravitch's (2010) complaint of quality improvement becoming transmuted into an accounting strategy created an unfulfilled consequence that RTTT may not be able to come to life given the rising controversies surrounding it (cf. Owens, 2009).

Integrated Mathematics and Science

The publication of *A Nation at Risk* (1983) report provoked the writing of more than 300 documents (Bybee, 1993), some of which addressed a perceived need for national benchmarks, standards, and assessment for mathematics and science "literacy" that not only improved student achievement scores, but also increased the level of student understandings (DeBoer, 1991). Standards-based curriculum reform of the 1990s called for integration, connections, and links between disciplines and specifically between mathematics and science. Science education and mathematics education researchers saw the need to create tests that demonstrated authentic understandings of the natures of science and mathematics, rather than just measuring the size of the student's reservoir of memorized facts (e.g., Champagne, Kouba, & Hurley, 1999). This work was just getting well underway when the Bush administration mandated NCLB. In NCLB reform, the learner-centered processes and concepts advocated by the standards and supported by the learning literature were diminished in the wake of requirements for high-stakes student assessment and teacher-school accountability (Hurley & Padró, 2006; Padró & Hurley, 2005), which from the perspective of critics of NCLB lacked both public discussion and a sound theoretical foundation (Ravitch, 2010).

While research has been conducted on IMS for at least 60 years (Berlin & Lee, 2003), a presence of integration through "theoretical models and empirical research related to IMS courses, projects, and programs for preservice and in-service teachers has emerged in the last 12 years" (Berlin & Lee, 2005, p. 22). From time to time throughout the 20th century, review articles reported on the literature of IMS and the progress of integration in classrooms. The most recent of these provided both positive and negative evidence for the status of IMS just prior to NCLB (Czerniak et al., 1999; Hurley, 2001; Pang & Good, 2000). Berlin and Lee examined the IMS literature from 1990 through 2001 and found an increase of publications related to courses offered in schools of education.

Assumption and Hypothesis for the Study

This paper was based on the assumption that locating course offerings in the days of NCLB reflects the value that college/university preservice teacher preparation programs place on the integration of mathematics and science. Using the method that Gould (1996) called "interviewing a document" for the analysis of a literature review guided the development of a national survey of preservice teaching programs identified as having IMS courses or approaches to teacher preparation during 2001-07. Both the literature review and the study focused on three questions:

1. What was the reasoning behind the offering of an IMS methods course?
2. What were its successes and challenges?
3. What is the future of the integrated course?

The hypothesis driving the study was that the emphasis by state report cards on reading/language arts and mathematics did not help improve the learning of math and sciences at P-12 because it caused schools to de-emphasize science and thus stifled different approaches toward preservice teacher preparation in these fields. By comparing findings to historical data, no difference in the extent to which an IMS model is used to prepare new math and science teachers would be found.

Research Design and Methodology

The study began with a literature review of primary studies reporting on integrations of mathematics and science in HEI methods courses from 1991 through 2009 (representing the presence of national standards) was conducted. While the studies did not have to meet specific methodology criteria, they did have to be teaching mathematics and science methods courses in some integrated fashion; report on the successes and challenges of their integrations; and have preservice teacher training for the elementary, middle school, or high school levels of instruction. Sixteen studies were found that met the above criteria, representing nine states (based on the home state of the first author or the state identified as the study location): California, Colorado, Connecticut, Florida, Maryland, Montana, Ohio, South Dakota, and Texas. Ten studies were at the elementary level, two studied middle schools, two involved high schools, and two studies covered both middle and high schools.

The second step of the research study, the design of a national survey, was done in four stages:

Stage 1. Schools of education (SOE) were located for all states plus the District of Columbia using the website, www.univsource.com, which listed a total of 557. A state was selected and the pilot study was conducted on all the SOE within that state to verify the accuracy of the website and to examine responses to the research questions, which originally numbered five.

Stage 2. As a result of the pilot study, two questions were dropped from the survey to simplify it. All SOE websites and catalogs in the nine states represented by the 16 studies were searched for IMS methods courses. States were assigned to a graduate student who searched each school's website and catalog. This work was double-checked by either a second graduate student or one of the researchers. Of the 140 SOE in the nine states, 52 showed IMS methods courses in their catalogs. These 52 schools were contacted via email and asked the remaining three research questions; one follow-up email was done.

Stage 3. Eleven states (Alabama, Arizona, Arkansas, Illinois, Kansas, Maine, Nevada, New Hampshire, New Jersey, New York, and Pennsylvania) were randomly selected from the remaining 41 states plus the District of Columbia to have their SOE websites and catalogs searched in the same manner as in Step 2. Out of 138 SOE in these states, 70 schools with possible IMS methods courses were located and contacted using email; one follow-up email was done. A total of 278 SOE (49.9%) were now fully searched, with 122 directly contacted based on preliminary information obtained.

Stage 4. The 279 remaining SOE in the United States (located in the remaining 30 states plus the District of Columbia) were assigned numbers and a random number generator was used to select 25% of these to contact by mail. The department chairs at these SOE received a letter, containing both research questions and a stamped return envelope, along with a request to pass along the information to any IMS professor(s); one follow up was done by email.

Results

From the Literature Review

Table 1 describes the reasons given in the different studies analyzed as to why IMS methods courses were provided. These reasons fit within three broad categories: compliance with standards, a desire for program reform, and philosophical reasons.

Table 2 describes the successes and challenges (Question 2) found in the literature during this time from pursuing an IMS model. Extracted from the 16 studies were indicators framing

Table 1: Reasons from the 16 Studies as to why Universities Offered IMS Courses

Compliance with Standards (national, state, or NCATE accreditation)	Reform (school, program, or policies)	Philosophical Reasons (Constructivism or beliefs about integration)
Briscoe & Stout (1996)	Berlin & White (2009)	Berlin & White (2002)
Frykholm & Glasson (2005)	Lewis, Alacaci, O'Brien, & Jiang (2002)	Kelly (2001)
Haigh & Rehfeld (1995)	Lonning & DeFranco (1994)	Kotar, Guenter, Metzger, & Overholt (1998)
Koirala & Bowman (2003)	Miller, Metheny, & Davison (1997)	Stuessy & Nazier (1996)
Kretschmer, Sia, & Bagheri (1991)	Moseley & Utley (2006)	
McGinnins, Parker, & Roth-McDuffie (1999)		
Stuessy (1993)		

the analysis of data relating to Question 3 (which are not fully discussed in this paper due to space limitations).

Responses from the pilot study (Stage 1) provided positive evidence that the use of information from the website, www.univsource.com, was accurate enough to continue to use in the remaining steps. It also provided evidence that some SOE were continuing to teach IMS methods courses at both the undergraduate and graduate levels, causing the researchers to continue to Stage 2. Based on feedback from the pilot study participants, the number of research questions was shortened from five to the three identified in the previous section.

Table 3 presents results from the 16 identified studies (Stage 2), the SOE in each state (n=140), the number of integrated methods courses located in catalogs (52), the number of surveys returned by state (17), and the number of integrated courses verified by state (seven total). The return rate for the 17 responses to 52 surveys sent out was 32.7%, with seven integrated methods courses verified in four of the nine states.

Table 2: Successes and Challenges of Using an IMS Model in Preservice Teacher Preparation Identified in 16 Selected Studies

Successes	Challenges
Statistically significant outcomes for preservice teacher confidence (Kelly, 2001)	Preservice teachers perceived that problem solving in integration was only pertinent to mathematics (Briscoe & Stout, 1996)
Statistically significant increased beliefs in science teaching efficacy after taking a newly developed integrated course (Moseley & Utley, 2006)	Preservice teachers had difficulties designing problems that demonstrated higher-level thinking, needing additional time to develop integration expertise in another study (Miller, et al., 1997)
Improved attitudes toward teaching integrated mathematics and science (Lonning & DeFranco, 1994)	Preservice teachers considered mathematics as only a tool for science (McGinnis, et al., 1999)
Positive attitudes toward problem-centered learning (Briscoe & Stout, 1996)	Preservice teachers had difficulty with the difference in language between mathematics and science and lacked preparation for teaching mathematics (Koirala & Bowman, 2003)
Improved reflectivity and problem-solving processes were perceived to develop (Stuessy & Nazier, 1996)	Preservice teachers became frustrated with the challenges of integration and the lack of seeing integration in middle schools (Koirala & Bowman, 2003)
Improved preservice teacher curriculum designs and the teaching of integrated units (Kotar, et al., 1998; Kretschmer, et al., 1991)	Preservice teacher attitudes toward integration was lower at the end of teaching and barriers and challenges were seen as greater (Berlin & White, 2002; 2009)
Development of analytical skills (Stuessy, 1993)	Preservice teachers questioned their content knowledge and their abilities to integrate curricula (Frykholm & Glasson, 2005)
Increased knowledge of mathematics and science (Frykholm & Glasson, 2005; Stuessy, 1993)	Preservice teachers, while remaining enthusiastic for integration, also reported a very heavy workload (Haigh & Rehfeld, 1995)
Perception of student benefits from integration remained constant from beginning to end in preservice teachers (Berlin & White, 2002; 2009)	
High level of student enthusiasm for the integrated course (Haigh & Rehfeld, 1995)	
Preservice teachers receiving extra integration training held deeper conceptual understandings of integration and practiced integration in their teaching (McGinnis, et al., 1999)	
Researchers felt their course was successful in linking theory to practice (Kretschmer, et al., 1991); others felt that philosophical, theoretical, and logistical problems were overcome (Lonning & DeFranco, 1994)	

Table 3: Nine Searched States Represented by 16 Research Studies of IMS Methods Courses for Preservice Teachers

States	No. Studies by State	SOE in	Integrated Courses Found	No. Surveys Returned	No. IMS Courses Verified
California	2	42	8	2	1
Colorado	2	9	4	2	1
Connecticut	2	7	2	2	2
Florida	2	12	5	2	0
Maryland	1	10	2	0	0
Montana	1	3	0	0	0
Ohio	2	20	9	0	0
So. Dakota	1	2	2	0	0
Texas	3	35	20	9	3
Total	**16**	**140**	**52**	**17 (33%)**	**7**

In Stage 3 (Table 4), 11 states were randomly selected to increase the number of states to 20 whose SOE websites and catalogs were searched. Representing 138 SOE, 56 integrated courses were located in their catalogs. Responses were received from 23 schools (32.9% response rate) that verified nine IMS methods courses in five of the 11 states.

At this point, 278 (50%) of the total SOE in the United States (557) were searched and surveyed. Surveys were then mailed to 69 (25% of the remaining SOE) randomly selected SOE that were located in an additional 25 states and the District of Columbia. This resulted in a return of 38 survey responses (55%). The number of verified IMS courses was five, as shown in Table 5.

Altogether, 347 (62.3%) of the 557 SOE in the United States had websites searched and/or were contacted directly for IMS methods course information. Overall, 78 SOE (22.5%) responded to surveys and 21 SOE reported the presence of IMS teacher education methods courses. This number represents 3.8% of SOE in the United States. Out of the 21 SOE reporting the presence of IMS teacher education methods courses, 20 of these actually provided reasons for the presence of the courses. These responses included the same three categories found in the literature review as well as additional reasons for integrating mathematics and science.

Table 4: Random Sample of 11 Searched States with Surveys Returned and IMS Methods Courses Verified

Random Sample of States	SOE in State	Integrated Courses Found	No. Surveys Returned	No. IMS Courses Verified
Alabama	17	3	0	0
Arizona	4	3	1	0
Arkansas	7	5	2	1
Illinois	24	11	5	1
Kansas	6	1	0	0
Maine	3	0	0	0
Nevada	2	1	0	0
New Hampshire	3	1	0	0
New Jersey	10	6	5	4
New York	32	16	4	2
Pennsylvania	30	9	6	1
Total	**138**	**56**	**23 (33%)**	**9**

Integration successes and challenges were addressed by 18 of the 21 survey respondents. Successes included: students realizing the connections between mathematics and science (nine); increased student comfort and confidence with science and math (four); enjoyment of science and math (two); reduction in anxiety (two); lowering of redundancies caused by separate science and math methods courses (one); and, students learned to teach mathematics (one). Two responses were too general to classify. More integration challenges than successes were reported by the 18 methods teachers. Twelve discussed the lack of time for teaching everything needed in an IMS methods course, four mentioned the presence of both math and science anxieties, four were concerned about the lack of mathematics and science conceptual understanding in students, three wrote of the difficulty in finding professors with expertise in both mathematics and science, three talked about the difficulty of doing a good job of teaching math and the use of manipulatives, while 10 identified other unique challenges that were largely contextual.

Table 5: Random Sample of 69 SOE in 25 States and D.C. with Surveys Returned and IMS Methods Courses Verified

State	SOE Randomly Surveyed	No. Surveys Returned	No. IMS Courses Verified
Delaware	1	0	0
Georgia	4	2	0
Idaho	4	2	0
Indiana	4	3	1
Iowa	1	1	1
Kentucky	4	3	0
Louisiana	4	0	0
Massachusetts	4	1	0
Michigan	5	3	1
Minnesota	2	1	0
Mississippi	2	1	0
Missouri	4	2	0
Nebraska	1	0	0
N. Carolina	5	3	0
N. Dakota	1	1	0
Oklahoma	3	2	0
Oregon	2	1	1
Rhode Island	2	1	0
S. Carolina	1	1	0
Tennessee	3	1	1
Utah	2	2	0
Virginia	1	1	0
Washington	5	5	0
Washington D.C.	1	0	0
W. Virginia	1	0	0
Wisconsin	2	1	0
Totals	**69**	**38 (55%)**	**5**

In regard to Question 3, 11 of the 16 studies (69%) indicated that they would continue to integrate, while 15 of 19 (79%) of respondents said they would continue to integrate. This national survey contacted a total of 347 SOE (62.3%) across the United States in a search for the existence of IMS methods courses. The survey produced a small percentage of SOE (ranging from 5% to 7.3%) that are persevering in the current climate. These percentages are larger than those integrations of math and science found by Wright in 1950 (3.5%), but similar to those found by Bossing in 1955 (6.6%).

Discussion

Both NCLB and RTTT are products of Foucault's governmentality, the way in which government formulates a strategy to ensure an aim is achieved invoking models of practice interpreted through the lens of government's description of its own actions (Padró, 2013; Gibbon & Ponte, 2008). Implementation of policy under both pieces of legislation raise evaluation questions of the interorganizational networks required to make them successful (DeGroff & Cargo, 2009). Using governmentality as a conceptual framework emphasizes how the effect of policy limits the response to change (Ball, 1994 as cited in Fimyar, 2008) in a variety of contexts (Gillies, 2008). NCLB and RTTT had/has in mind documenting improvements in student learning, but under NCLB the gains in reading/language arts and mathematics came at the expense of other subjects. Results have been mixed as demonstrated by the National Assessment of Educational Progress (NAEP) math test scores: scores for fourth and eighth grades between 1990 and 2005 have increased, but the percentage of students performing at the basic level did not improve during this time (Kuenzi, 2008). The question now is whether RTTT's system-wide demand for STEM education will generate the desired documentable level of student learning that eluded NCLB in spite of the big assumptions held by proponents of the Act. What the research here shows is that looking at the education reform efforts of the late 1990s and beginning of the 21st century presents a picture that discourages differentiation and experimentation in finding better ways to teach math and science as reflected in how preservice teachers are prepared to teach these subjects.

Kegan and Lahey (2001) talk about the notion of *competing commitments* based on *big assumptions*. With states having to report on school performance based on test score results for reading/language arts and mathematics, there seems to be at least a *prima facie* connection. The competing commitments are demonstrating improved performance in the two key reporting areas by reducing instructional time for other subjects. The big assumption is that the most important thing is to be compliant where one has to be. This makes compliance a zero-sum game based on a strategy that minimizes an institution's maximum loss (Padró, 2013). Arguably, the effect on preservice teacher education can be seen in the discrepancy between catalog descriptions and verified IMS courses in Tables 4 and 5, where there are fewer verified courses.

RTTT has some similarities with the National Defense Education Act of 1958 (NDEA) regarding targeting funds through grants for specific priorities. Although originally envisioned as short-term emergency legislation, its long-term impact on strengthening science, mathematics, and foreign languages (Title III) was deemed successful, particularly in the 1960s (Flattau et al., 2007). State surveys from the period suggested that "that better equipment and teacher training contributed to students' increased interest in Title III subjects" (p. III-4). One major difference between RTTT and NDEA, however, is that the latter was a reform movement based on collaboration between teachers and researchers (Jolly, 2009). As this has not been the case under NCLB and the grant process behind RTTT, the challenge that RTTT has to overcome is how both scientists and teachers have concerns on how high-stakes testing can inhibit effort to improve science education (Taylor, Jones, Broadwell, & Oppewal, 2008; Owens, 2009).

This national survey contacted a total of 347 SOE (62.3%) across the United States in a search for the existence of IMS methods courses. The survey produced a small percentage of SOE (ranging from 5% to 7.3%) that are persevering in the current climate, an increase from 1949, but not that much more from 1954. World War II is often blamed for the slowing of the integrated curriculum movement (e.g., Harvill, 1954); however, some blame the countertrend on how the federal government responded to Sputnik (Cohen, 1978). Nevertheless, Hurley's (2001) meta-analysis of the literature on integrated curriculum indicates that IMS has continued to generate interest as a viable preservice teacher preparation and school teaching model.

Conclusion

A report of this study's findings was first given in 2007 at the School Science and Mathematics Association annual conference (Padró & Hurley, 2007). At the time, only 14 studies had been identified as part of Stage 1 of the study. Subsequent reviews of the literature up to 2011 identified another two studies, and the additional data from these two studies were incorporated into the analysis. The inclusion of the studies did not alter results. Rather, revisiting and expanding the literature review from data collected during the time NCLB was officially in effect provides what Lincoln and Guba (1985) called *prolonged engagement* as a means to increase the probability of credible findings. The literature on IMS from 1991 to 2009 purports a preponderance of evidence supporting the teaching model in preservice teacher preparation (Table 2). Yet, AYP state report cards emphasizing reading/language arts and mathematics mean that NCLB took time away time from teaching other subjects, making science a low priority, especially at K-8 (Owens, 2009).

The benefits of an integrated curriculum model have been around since the *Eight Year Study* commencing in 1933 (Aiken, 1942). Yet, the mandated improvements under NCLB seem not to be too different than that found in the 1930s. What does this augur for RTTT? STEM, as a model for integration could encourage integration (e.g., Veenstra, Padró, & Furst-Bowe, 2012). RTTT Priorities 2 and 5 address STEM; however, RTTT may also not fully succeed in meeting expectations because the accounting mentality Ravitch (2010) refers to can still reduce focus to those measures defining accountability.

Under NCLB, IMS languished because science was not part of the AYP report card. Test scores in reading/language arts and mathematics improved, but this came at the expense of reduced time teaching other subjects, including science. Even then, in mathematics, NAEP scores showed that student performance at the basic level did not improve from 1990-2005 (Kuenzi, 2008) and the proportion of students not reaching the Program for International Student Assessment's (PISA) baseline Level 2 has not changed between 2003 and 2012—while performance in reading and science also has not changed much over time, remaining near the OECD average (Organization for Economic Cooperation and Development [OECD], 2013). One of the limitations students showed in math was the lack of applicability of mathematical concepts to real-world problems. The chances of RTTT succeeding when previous efforts fell short do not seem high given the track record.

Based on the evidence found in this study, it is difficult to disagree with Cody's (2013) argument that *groupthink* is at play in establishing educational policy and its consequences or agreeing with Marcuse's (1964) view of social one-dimensionality. The unintended consequences of NCLB in preservice teacher preparation programs may not dissipate because policy steering continues to define quality from a similar lens in RTTT. The creation of the Common Core is seen as a potential solution to improve PISA results (OECD, 2013), but even this report points out that there are other, non-curricular issues at play as well based on achievement gaps by low-socio-economic and minority students.

An often-used statement is that quality education depends on quality teachers. Results from focusing on mathematics and literacy have not generated expected results. It makes sense to take a serious look at classroom pedagogies and preservice teacher preparation to propose and support these new pedagogical models. Policy driving educational reform is not about pedagogical experimentation, however, it is more about test taking rather than focusing on the elusive target of actual, meaningful student learning.

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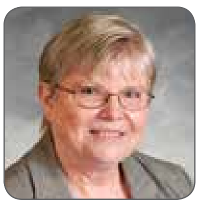

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