The Mediating Role of Coherence in Curriculum Implementation

William Penuel, SRI International, 333 Ravenswood Avenue, Menlo Park, CA 94025-3493, william.penuel@sri.com
Barry J. Fishman, University of Michigan, 1301 Beal Ave, Ann Arbor, MI 48109-2122, fishman@umich.edu
Lawrence P. Gallagher, Christine Korbak, Bladimir Lopez-Prado
SRI International, 333 Ravenswood Avenue, Menlo Park, CA 94025-3493,
Email: lawrence.gallagher@sri.com, christine.korbak@sri.com, bladimir.lopez-prado@sri.com

Abstract: Implementation of inquiry-based curriculum materials has been a challenge in science education. Recent research points to the importance of *coherence* in professional development as a means to improving implementation. Policy researchers have defined coherence in terms of alignment of standards, curriculum, and assessment is key to supporting implementation, while teacher learning researchers have analyzed coherence as an aspect of teachers' perception influenced by features of their professional development. This paper presents an expanded model of coherence that focuses on teachers' perception of alignment of curriculum materials that are the focus of professional development and on the fit of the materials to their local school context. Using empirical data from a state-wide systemic inquiry science reform effort targeting students from kindergarten to eighth grade, we describe how these two factors influenced teachers' global perceptions of the coherence of their professional development activities and subsequent implementation of curriculum materials.

The science education community has long promoted the use and development of curriculum materials that emphasize student inquiry. Over the decades, there has also been another, problematic, consistency across these curricula: difficulties in implementation. This paper focuses on the topic of curriculum implementation, using empirical data from a state-wide systemic science reform effort targeting students from kindergarten to eighth grade. In particular, we examine the construct of *coherence* and how teachers' understanding of their local school context and of the particular curricular innovation within their local context influences curriculum implementation by individual teachers.

The idea that curriculum innovations must fit within their local context has been a central concept in two areas of research that have received significant attention in the past decade. A number of scholars who have examined the failures of implementation in past reforms in science education have pointed to the need for better alignment among national and state policies, standards, curriculum, and assessments (e.g., Smith & O'Day, 1991). Without good alignment, teachers face a conflicting configuration of demands on their practice that is difficult for them to interpret and act upon (Fuhrman, 1993a). Other researchers have focused on the need for quality professional development that is coherent with their own goals and their school's goals for student learning (Garet, Porter, Desimone, Birman, & Yoon, 2001).

An alternative perspective is that failures of coherence and implementation can arise from teacher autonomy and local school capacity. When teachers have autonomy in choosing from an array of curriculum materials to teach a particular set of standards, they may not use guidance professional developers provide them about what activities align to particular standards. In addition, when perceived and observed demands of curricula exceed schools' capacity to support implementation, teachers may not judge their professional development experiences to be coherent. In contrast to earlier policy and teacher learning models of coherence, our model of what contributes to teachers' perceptions of the coherence of their professional development activities related to a specific curriculum and to higher levels of curriculum implementation emphasizes problems of agency inherent in reform activities (Rowan & Miller, 2007) and the fit of an innovation to the capacity and constraints of a local school (Blumenfeld et al., 2000).

We illustrate our model empirically by focusing on professional development activities related to an inquiry science program being promoted by a state department of education. In the context for this study, reformers "did everything right" with respect to aligning policies, standards, and curricula and with respect to providing high-quality professional development to teachers, but rates of curriculum implementation were low. In a multi-level analysis of 225 teachers who participated in workshops in summer 2006, we found that what predicted teachers' implementation rates were teachers' own interpretations of what standards could be taught using the curriculum materials. These interpretations, as well as teachers' perceptions of school-level barriers and resources predicted teachers' judgments of coherence of the innovation within their local teaching context.

Background and Theoretical Framework

The Construct of Coherence in Educational Policy Research

Policy researchers have often attributed the failure of policies to impact classroom practice on a lack of coherence across the educational system. Part of the incoherence stems from the fact that education is a complex system in which decision-makers at different scales of the system do not always share common goals (Fuhrman, 1993a) or facilitate the flow of knowledge about policies throughout the system (O'Day, 2002). Many policies address only one aspect of the system (e.g., testing but not curriculum) and thus fail to take into account the different levels of the system and timescales of educational change (Knapp, 1997). As a result, teachers face a configuration of demands that often contradict one another and thus do not provide clear guidance for action (Fuhrman, 1993b).

This type of coherence might be called *policy alignment,* since scholars pointing to the need for greater coherence within the system have argued that improving coherence requires better alignment among national and state policies, standards, curriculum, and assessments (Herman & Webb, 2007; Knapp, 1997). In fact, a defining feature of standards-based reform in education is that it does not just seek to define standards but also seeks to create and implement assessments and accountability structures that are aligned to those standards (Herman & Webb, 2007). A core assumption behind efforts to improve alignment is that it will result in guidance to teachers that they can follow, leading to impacts on teacher cognition and practice.

The Construct of Coherence in Teacher Learning Research

In research on teacher learning from professional development, a different definition of "coherence" has been defined and measured largely from the teacher's point of view. For example, Garet and colleagues (2001) define coherence in terms of teachers' interpretations of their professional development experiences. Their six-item scale for coherence includes questions about teachers' perceptions of how well aligned activities are to their own goals for and trajectories of professional development, reform ideas in their school, and frameworks for curriculum, instruction, and assessment at the district and state level. As such, their measure of what we would call *global perceptions of coherence* encompasses the two definitions of coherence from policy research but foregrounds teachers' interpretations of alignment and program coherence at the school level.

In their study of what constitutes effective professional development, Garet and colleagues (2001) found global perceptions of coherence to be related to self-reported changes in knowledge and practice in mathematics and science instruction. In addition, three features of professional development were related to perceptions of coherence in their model: time span, total hours, and collective participation. The longer the time span over which activities were spread, the more hours teachers participated, and the greater degree of co-participation in activities with other teachers from their school or district, the more likely teachers were to see professional development activities as coherent.

An Integrated Model of the Coherence of Professional Development

The perspective we explore in the current study seeks to unpack or explain coherence in a way that includes elements of the policy and teacher learning research definitions and models, as well as two other factors: teacher agency and the fit of innovations within their local context. Just as teacher learning research examines context from the point of view of teachers, we take teachers' perspectives on the innovation as our starting point. But we also hypothesize that policy alignment has an important contributing role to play in fostering perceptions of coherence. Third, we consider that the array of materials teachers have available to teach particular standards can act as a potential constraint on coherence and implementation. Finally, we include in our model of what contributes to coherence measures of how the fit of the innovation within the constraints and capacities of schools, such as accountability pressures and structured time for implementation planning, can contribute to coherence (see Figure 1).

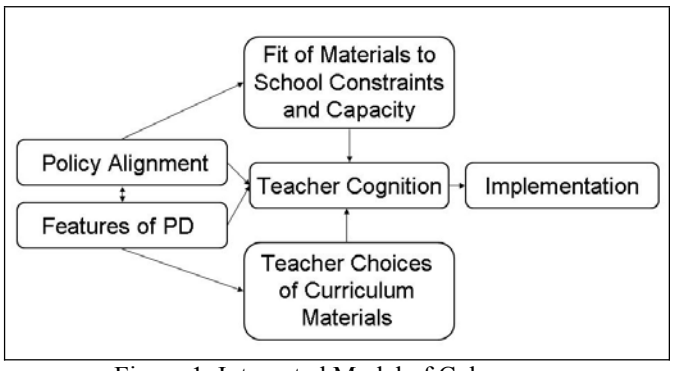

Figure 1. Integrated Model of Coherence.

Our reason to begin with teachers' perspectives on coherence derives both for our appreciation of the mediating role of teachers' interpretation of reforms on implementation described above and from our acknowledgment that teachers in science education today still have considerable autonomy in selecting curriculum materials. Even if there is good alignment among instruction, curriculum, assessment, and professional development and the professional development that teachers receive is aligned with research on best practice, teachers may still choose not to implement a particular program or curriculum.

Because teachers may not share the same goals as those interested in reform, reformers face what can be called a problem of agency (Rowan & Miller, 2007). In contexts where there are agency problems, so called "principals" (in this case, reformers) must develop means to persuade or coerce "agents" (in this case, teachers) to carry out their goals. Where teachers have a choice in the materials they use, either because they draw on textbooks purchased through their school districts, on worksheets and materials obtained from competing materials, or even on activities they design themselves, it may be particularly challenging for any particular reform organization (including a state or district) to convince a teacher to adopt a particular program.

Policy alignment and professional development can be related to one another in such a way as to enhance or reinforce messages to teachers about the legitimacy of implementing a particular innovation. An example would be when a state or district, in adopting a particular instructional reform, supports implementation with extensive professional development paid for and sanctioned by the state or district. In this particular paper, we focus on such an example at the state level, and since all teachers received professional development with the features Garet et al. (2001) identified as contributing to coherence, we focus principally on elements of professional development designed specifically to influence teachers to believe the particular innovation we are studying is aligned to state standards. These elements include documents and artifacts that demonstrate linkages between standards and particular activities. We also recognize other resources (e.g., materials, equipment) that professional development providers can offer teachers may be essential features that contribute to coherence, insofar as the allocation of adequate resources to a curriculum signals its legitimacy and value.

Beyond agency, the fit of an innovation within the constraints and capacity of schools to adopt particular instructional practices and curricula are likely to influence global perceptions of coherence in our model (Blumenfeld et al., 2000). One such constraint may be accountability systems, which influence the pressures on schools to adopt particular curricular remedies for low achievement. Another constraint may be requirements and demands of new instructional practices themselves. Sometimes the nature of those demands conflicts with the organization of the school. Inquiry curricula in science often require extensive planning and preparation, something that is often lacking. Innovations that make extensive use of technology require sufficient access to technology and capacity to support that technology. Therefore, teachers' judgments of coherence are likely to be influenced by the interaction between the demands placed on them by curricula and the resources they have available to them.

The Current Study

The current study focuses on the sources of teachers' implementation and judgments of coherence of the GLOBE Program, an international program in Earth science and Earth science education. GLOBE provides curricular materials for use in classrooms, as well as an online database that is directed at supporting the work of scientists investigating aspects of the global environment. At the beginning of GLOBE, scientists funded as GLOBE Principal Investigators by the National Science Foundation developed a set of protocols for students to use in four distinct investigation areas related to earth systems: Atmosphere, Hydrology, Soils, and Land Cover/Biology. GLOBE schools collect the data according to the protocols. GLOBE expects teachers to implement the protocols for the program. To collect data, students are expected to use GLOBE-certified equipment set up in a way specified by scientists in the program. In addition to collecting data, GLOBE expects teachers to report data to the GLOBE Web site. Reporting data benefits scientists by making student-collected data available for their own investigations. Past studies have shown a positive relationship between gathering, posting, and discussing data and student learning outcomes (Penuel et al., 2002).

One of the places where GLOBE has been implemented with a great deal of attention is in the state of Alabama, where the program is implemented as part of the Alabama, Mathematics, Science, and Technology Initiative (AMSTI). AMSTI is a state-wide program funded by the Alabama Department of Education that was designed by a blue-ribbon panel to improve mathematics and science instruction across the state. The focus of AMSTI is on science in grades kindergarten through eighth grade. Besides GLOBE materials, other curriculum materials that are included as part of AMSTI training are science kits from the Full Options Science System (FOSS) program and from the Science and Technology Concepts (STC) program. FOSS and STC curriculum materials receive greater emphasis than do GLOBE materials in AMSTI, but officials stress that the GLOBE materials address key standards not addressed through the FOSS and STC kits. In addition, GLOBE protocols provide more direct encounters with the work of scientists than do the inquiry kits, in that scientists are expected to use GLOBE data from students in their own investigations.

The AMSTI initiative is an ideal context for studying the coherence of GLOBE as a curricular innovation in that several important elements typically believed to be integral to promoting implementation are part of the initiative. First, AMSTI attempts to build district-level and school-level buy-in to its activities by selecting schools, rather than individual teachers, to be a part of AMSTI through a competitive application process, (see, e.g., Cooper, Slavin, & Madden, 1998). As part of the application, schools must demonstrate that 80% of the mathematics and science faculty want to take part; if selected, all teachers from the school become participants in the initiative at no cost to the school. A second way that AMSTI promotes implementation is by providing teachers with clear instructional guidance (Rowan & Miller, 2007). The initiative not only provides teachers with specific GLOBE activities to implement in their classroom, but it also provides them with guidance on how and when to incorporate them into their instruction. Standards linkage documents show how specific GLOBE activities meet specific standards in each grade level. Third, AMSTI's activities to prepare teachers to implement GLOBE has characteristics associated with effective PD (Garet et al., 2001; Authors et al., in press). AMSTI PD includes a two-week summer institute (during which teachers participate in 2 days related to GLOBE), equipment and materials, and follow-up support through specialists who are associated with regional science centers across the state. Finally, AMSTI has built in evaluation and feedback mechanisms for accountability purposes and for ongoing program improvement, which are essential features of contemporary standards-based reform models. The program has published results from external evaluations on its web site, which document how student achievement in mathematics and science among AMSTI schools compare with achievement in non-AMSTI schools.

Despite the strength of the policy and PD supports for GLOBE implementation established through its integration into AMSTI, the data we present in this study show that the vast majority of teachers who took part in the initiative in the past year did not implement GLOBE protocols with students in their classrooms. Furthermore, although most teachers perceived the program as consistent with their own goals for PD and with district and state expectations for student learning in science, nearly one-fifth (17.7%) of teachers who responded to our questionnaire rated GLOBE materials as "not sufficiently" consistent with these goals. Both these results trouble AMSTI officials at the state level, both because they limit the potential impact of the initiative on achievement and because they call into question the efficacy of their efforts to create strong alignment of GLOBE to state standards and curriculum frameworks. As our statistical models below suggest, however, much of what appears to be driving teachers' implementation and perceptions of coherence are perceptions at the individual level of materials alignment and of the local school context.

Research Methods

Sample

The sample for the study was comprised of 423 teachers who attended AMSTI PD in summer 2006. All teachers who participated in PD completed a background questionnaire, in which we collected contact information from participants for later follow-up. A total of 225 teachers from 51 different schools completed our full questionnaire, a response rate of 53%. Teachers in the study came from schools that were representative of Alabama schools. A total of 29 schools in the sample or 57% had met criteria for Adequate Yearly Progress (AYP) according to federal *No Child Left Behind* guidelines. That compares with 53% of schools statewide that met AYP. The student body was 34.4% minority (primarily African American) and 55.9% of students were from low-income families. Statewide, 40.8% of students were minorities, and 43.0% were low-income. Roughly half of the teachers in the sample had a MA degree or higher, but only about one fifth had teaching certificates in science. This is explained by the sample composition, which consisted primarily of teachers who taught science at the elementary level. On average, teachers had 11.5 years experience in the classroom (SD = 8.8 years) and 9.2 years experience teaching science (SD = 7.7 years).

Sources of Data

Dependent Variables

Teacher Questionnaire: Global Perceptions of Coherence. We incorporated into our questionnaire a six-item factor (α = .93) that measures how well PD matched the teacher's goals, the existing reform ideas within the school, and whether the PD was followed up with activities that built upon what was already learned.

Teacher Questionnaire: GLOBE Protocol Implementation. Use of GLOBE protocols with students were used as a measure of program implementation. Teachers indicated for each protocol whether they had implemented, planned to implement, or had not implemented the protocol and did not plan to do so. Using their responses to the questionnaire, we created an index that a weighted sum of their intentions and actions across GLOBE's different investigation areas.

Teacher Level Independent Variables

Perceptions of Alignment of GLOBE with Alabama Course of Study Science Content Topics. We focused our questions about teachers' perceived alignment of GLOBE with state content standards. We tailored

items for each K-8 cluster of grade levels for which the standards are written: K-2, 3-5, and 6-8, and asked teachers to rate whether they covered the standard using GLOBE or some other set of materials. We created an index of the sum of the number of standards teachers said they could meet using GLOBE materials.

Use of Alignment Tools and Artifacts from Partner. The GLOBE in Alabama partnership has developed an alignment tool that is posted on its Web site (http://www.globe.uah.edu/linking.htm). We asked teachers about their familiarity with this tool and also how/whether they had used it in making decisions about whether or how to implement GLOBE.

Barriers to Implementation. We asked teachers to identify whether each of seven types of barriers derived from earlier evaluation studies of the GLOBE program (Authors et al., in press). These barriers were: difficulty finding time to prepare for implementing GLOBE, lack of technology access, lack of technical support for using computers and software, lack of GLOBE equipment, unsupportive school building administrators, and unsupportive district administrators. Teachers indicated whether each potential barrier to implementation was a major barrier, minor barrier, or not a barrier. For purposes of analysis, we analyzed barriers in three separate clusters. The first item, difficulty finding time to plan for implementation, was analyzed as a single categorical variable, recoding "major barriers" as 1 and "minor barrier" and "no barrier" as 0. The next three barriers related to equipment and technology had good reliability as a scale ($\alpha = 0.73$), so we analyzed them together. The last two items related to school and district support also had reliability adequate for constructing a scale ($\alpha = 0.89$), so we analyzed those items as a single scale.

Support for Equipment Use. Because we found that partner support for equipment use were significant predictors in our earlier PD study of GLOBE implementation (Authors et al., in press), we included items used in our original study as dummy variables in the analysis. Equipment use support is a single survey item which asked teachers if the GLOBE partner provided assistance on technical setup and equipment use. This is a binary variable where 0=no and 1=yes.

Teacher Characteristics. We included items asking teachers about their certifications, education, and years experience teaching, gender, and ethnicity as control variables in the analysis.

School-Level Independent Variables

State Assessment Data: Achievement Levels of Schools. We categorized schools in our sample on the basis of whether the school met "Adequate Yearly Progress" in both reading and mathematics for all grades and subgroups. AYP status was measured as a dichotomous variable in our analysis. We anticipated that AYP status could affect implementation levels either by diverting attention away from science (since AYP status is based on mathematics and reading scores, not science scores) or that teachers in schools meeting AYP status might feel less pressure to adopt state-approved science curriculum materials.

Number of GLOBE Teachers in the School. We included the total number of GLOBE teachers in the school as a school-level variable. Since the policy was that teachers were expected to participate as part of a school team, we reasoned that the number of GLOBE teachers in the school might have a positive effect on perceptions of coherence and GLOBE implementation.

Data Analysis

We analyzed our data at two levels: teacher and school. Because of the nested structure of the data set, we used hierarchical linear modeling (HLM) to examine the relationship between effects of individual teachers' perceptions of alignment and use of alignment tools, interpretations of barriers, and experiences of support (Level 1) and the effects of school AYP status and number of GLOBE teachers in the school (Level 2) on teachers' global perceptions of the coherence of GLOBE and implementation. For each of our two outcome variables, the extent of the influence of the initiative on teachers' practice, we first conducted an unconditional model to determine the variance structure at each level. We then constructed a model for each outcome variable that analyzed the hypothesized links between knowledge transfer processes and reform implementation.

Results

Descriptive Statistics

Coherence and Protocol Implementation

On average, teachers' judged the coherence of GLOBE with their own and their district's goals for student learning to be "sufficient," but implementation levels were low. On a scale from 0 to 3, with 0 being "not at all aligned" and 3 being "very well aligned," teachers in the sample rated the coherence of GLOBE as $M = 1.9$ ($SD = 0.57$, $n = 221$). With respect to implementation, roughly one-quarter of the teachers reported that they had implemented protocols that were part of the Atmosphere protocol, and 14% reported they had implemented GPS protocols. For the other investigation areas, less than 10% of teachers reported implementing any of these. On average, teachers scores on the index we constructed to measure protocol implementation were 2.6 ($SD = 2.2$, $n = 221$).

Coverage of Standards Using GLOBE and Use of Linking Documents

On average, teachers reported that they used GLOBE to cover 5.0 (*SD* = 6.2, *n* = 221) different content areas in the Alabama Course of Study, the state's content standards. Only a about a quarter (26% or 56 of 213) of teachers, however, reported they used the linking documents provided by AMSTI to help guide their thinking about alignment to standards. Only 8.5% used these documents to make decisions about how to use GLOBE to replace existing materials in their curriculum.

A closer examination of teachers' reports of how they used GLOBE by standard reveals that teachers' decisions about what topics to use GLOBE materials to cover standards to map well onto the AMSTI program's guidance. In many instances, only a small percentage of teachers used GLOBE to teach particular standards the program believed GLOBE could help teach. In other cases, teachers reported GLOBE could help them meet standards the program did not identify as linked to that standard. In grades K-2, for example, just 20% of kindergarten teachers used GLOBE to teach about the basic needs of living things, even though the AMSTI program identified that as a standard that could be met by using GLOBE materials. By contrast, 61.9% of second grade teachers said they used GLOBE materials to teach students how to identify evidence of erosion and weathering of rocks, even though the program did not show a linkage between GLOBE and this standard .

In the upper elementary grades, there were differences between the AMSTI perspective on standards linkage and teachers' perspectives. More than 30% of third grade teachers said they used GLOBE materials to teach students about how energy from the sun is used, but there was no official linkage to this standard. By contrast, just 38.5% said they used GLOBE materials to cover the standard related to identifying cloud types associated with specific weather, which GLOBE materials address, according to AMSTI. At the middle grades, the agreement between teachers' perceptions of alignment and AMSTI linkage documents is stronger in sixth grade than in grades seven and eight. Still, in all three grades, as with the elementary grades, there are significant differences between teachers' perceptions of content alignment and the program's official guidance.

Barriers and Supports to Implementation

The most significant barriers to implementation reported by teachers were inadequate time to prepare and plan for implementation and limited technology access and support (see Figure 2). Limited principal and district support were barriers to only a small percentage of teachers. For the one support variable in our models, help with setting up GLOBE equipment, 36% (*n* = 80) reported they received this type of support.

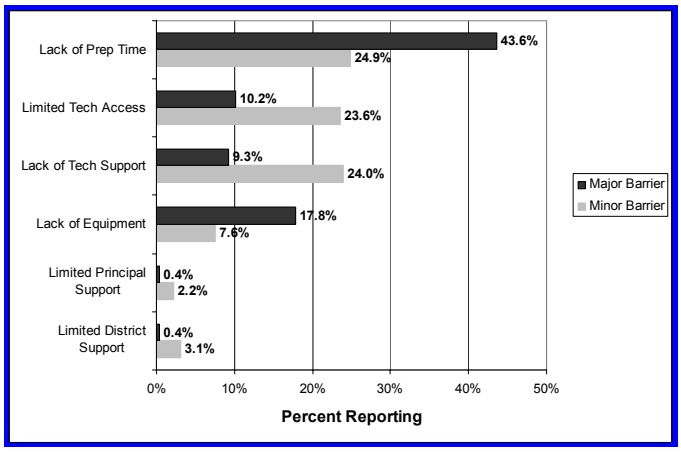

Figure 2. Barriers to implementation.

School-Level Variables: AYP Status and Number of GLOBE Teachers in School

A total of 29 schools (57%) in the sample had met Adequate Yearly Progress according to federal *No Child Left Behind* guidelines. There was a mean of 2.1 GLOBE teachers in the schools in the sample (*SD* = 6.2).

HLM Results

For the model testing the effects of the teacher- and school-level variables on teachers' perceptions of coherence, the significant predictors were teachers' use of GLOBE materials to cover content standards, lack of time to prepare to implement GLOBE, and school AYP status (see Table 1). The more standards that teachers reported that used GLOBE materials to cover, the higher their perceptions of coherence of the innovation with local goals for student learning. Conversely, when teachers lacked time to prepare, they reported less coherence. Teachers in schools that met AYP were less likely to view GLOBE as coherent with their local goals. None of the teacher background variables used as controls in the model was significant; therefore, we eliminated them from the models. Just one of the predictors included in our models predicted implementation levels of protocols.

Teachers that reported they used GLOBE to cover more standards were more likely to implement more protocols. This result is hardly surprising, since these two items are closely related. Teachers' use of linking documents was a significant predictor of implementation, but only at the $p = 0.12$ level.

Table 1. HLM Results

	Coherence		Protocol Implementation	
Level/Variable	*Coefficient*	*Standard Error*	*Coefficient*	*Standard Error*
Teacher Level				
Use of GLOBE to Cover Standards	0.02*	0.01	0.10***	0.03
Use of Standards Linking Documents	0.07	0.07	0.44	0.27
Lack of Time to Plan and Prepare	-0.12*	0.05	-0.05	0.23
Difficulties with Equipment and Technology Access	-0.05	0.04	0.09	0.17
Lack of principal and district support	0.01	0.04	-0.17	0.15
School Level				
School AYP Status	-0.18*	0.09	-0.26	0.35
Number of GLOBE Teachers in School	0.00	0.00	-0.01	0.01
Intercept	2.07	0.12	2.25	0.50

*$p < .05$, **$p < .01$, ***$p < .001$

Discussion and Conclusion

The results of this study suggest that there are at least some instances where alignment of curriculum materials with policies at the state level is not sufficient to promote a strong sense among teachers that particular curricular innovations are coherent. The AMSTI initiative was a carefully crafted state-level science reform initiative, of which GLOBE was an integral part. Efforts to persuade teachers of the coherence of GLOBE by providing them with specific instructional guidance about how GLOBE's curriculum materials aligned to state standards were largely unsuccessful, with teachers' judgments about the suitability of materials for teaching standards diverging widely from those of policy makers and professional developers in the program. Further, despite efforts to promote a comprehensive approach to science reform in schools by inviting school-wide participation, the number of teachers participating appeared to have little impact on teachers' perceptions of coherence or on their use of the GLOBE materials.

Similarly, AMSTI PD, despite its strong design, had little impact on coherence or implementation. Teachers' initial workshops included many opportunities for hands-on practice with protocols; a system of mentors was also accessible for classroom-based support. Teachers also received all the equipment they would need to implement their GLOBE protocols as part of the PD, a factor we have found in past research (Authors et al., in press) can influence implementation of GLOBE. Still, teachers' ratings of the coherence of PD were modest, given these strengths, and their implementation levels were disappointingly (to program leaders) low.

A frequent conclusion from research on implementation is that "more PD is needed," but our study suggests this recommendation is incomplete. The factors that contributed to teachers' judgments of coherence were at the local level, not easily influenced by policy makers or PD providers. For example, teachers' perceptions of alignment of materials to standards are likely a function both of their knowledge of curriculum and curricular purposes and of their subject matter knowledge. Teachers may possess erroneous conceptions of the meaning of standards (Smith & Southerland, 2007), in which case representations of alignment by developers are unlikely to be helpful. Their judgments may also be affected by the sheer number of curricular resources from which they have to choose; their authority in being able to choose these materials means that PD providers promoting a *particular* curriculum face significant competition for teachers' attention. Variety in conjunction with poor understanding of the meaning of standards may combine to lead teachers to interpret thoughtfully designed and coherent curricula into sequences of activities that can be broken up and combined with other district-provided materials, leading to incomplete or incoherent implementations of curriculum materials (Blumenfeld et al., 2006; Author et al., 2006). The lack of planning time is similarly a problem at the local level; more PD would not address this problem, if the teachers still do not have time to set up GLOBE equipment, plan for data collection, and select learning activities to use in conjunction with GLOBE protocols.

Our findings do not imply that nothing can be done to improve teachers' judgments of coherence of curricular programs. For one, the lack of an effect of policy-level alignment (which would likely have been evident if lack of administrator support had been a big barrier to implementation) does not imply that alignment

is insignificant. We conducted our study in one state context, where alignment was not something that varied by teacher. More significantly, we identified at least one component of an implementation model that may be important to specify for inquiry science curricula like GLOBE. The need for adequate planning time was critical for helping teachers understand the coherence of GLOBE with their goals for teaching and learning. Programs like GLOBE might do well to require or at least inquire about teachers' available planning time and to consider when, where, and how teachers will be able to plan for enactment.

The role of accountability pressure was significant as well, but its effect cannot easily be interpreted with the data available to us in our study. When schools failed to meet AYP, teachers in those schools were more likely to perceive GLOBE as coherent with their goals. The reason could be that those schools were under pressure to follow state guidance such as is provided by AMSTI and that following such guidance improves local confidence in those schools. Schools meeting AYP simply have had more discretion about how to use materials than schools not meeting AYP. Whatever the reason, accountability pressure is yet another significant factor at the local (school) level that influences judgments of coherence and that has little to do with the nature and amount of PD teachers receive.

An important limitation of this study is that it is a test of our own interactive perspective on coherence in a single state context. Our sample, though representative of those teachers and schools participating in GLOBE in one state, is not necessarily representative of teachers in the program elsewhere. Different contexts, therefore, might yield different estimates of the predictors of coherence. This study does suggest that an exclusive focus on alignment at the state level or on teacher PD models that do not take into account school-level constraints on teacher cognition and action can result in poor curriculum implementation. This finding is likely to be sobering to the Learning Science community in its efforts to scale up reform using standards-based curriculum materials. Further, it is one more reminder of how the complexity of the educational system makes it difficult to effect broad changes in instructional practice.

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