MATHEMATICS PROFESSIONAL DEVELOPMENT THAT FOCUSES ON STUDENT ACHIEVEMENT: A PARALLEL CASE EXAMPLE

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The creation of a PreK-8 Mathematics Specialist credential provides an unprecedented opportunity for Virginia school leaders to improve student achievement in mathematics. If this opportunity is to yield hoped for outcomes, the professional development that supports shifts in teachers' understanding and practice will need to be far more focused, coherent, and job embedded than most current mathematics improvement efforts. This article examines four issues to address this challenge. First, it notes the depth of the changes in knowledge, skills, and beliefs that a substantive move toward National Council of Teachers of Mathematics reform driven and standards-based instruction will require. Next, it presents an integrated model for professional knowledge growth that considers both individual and organizational factors. Third, it examines the prevalence of both individual and organizational factors as described in a study contrasting professional development practices in high poverty Virginia elementary schools that varied markedly in their success in reducing the number of kindergarten children assessed as at risk for reading failure. Concurrently, it outlines features of professional development that support the implementation of effective mathematics improvement efforts. While the knowledge base required for effective reading instruction is different from the knowledge base needed to inculcate best instructional practice in mathematics, the approach to professional development efforts and the role of content specialists in supporting those efforts may provide insight that can help frame mathematics improvement efforts.

Thompson and Zeuli describe the challenges to substantive reform in mathematics instruction and highlight the complexity of the reform effort.

> Any serious policy—that is, any policy that does not simply endorse existing practice and call for more of it—requires some learning on the part of those who must implement it. To carry out policies based on the proposed reforms will require a great deal of learning—not merely additive learning (the addition of new skills to an existing repertoire), but transformative learning (thoroughgoing changes in deeply held beliefs, knowledge, and habits of practice) [1].

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Thompson and Zeuli examine "what it would take to get the content and pedagogy of professional development right on a very large scale." [1] They contend that reformers and policymakers in science and mathematics should attend to the aspects of curriculum with which teachers have the most trouble. What they note is that change in teacher learning and practice is uneven and at times contradictory.

> Cohen's colleagues in the California Study of Elementary Mathematics (Peterson, 1990) found, at most, similar interminglings of newer and older practices without much recognition of the contradictions among the conceptions of content, teaching, and learning that undergird the disparate elements (Ball, 1990; Peterson, 1990; Wiemers, 1990). In fact, the one teacher who rejected the reform ideas seemed more aware of the differences than did the teachers who adopted them (Wilson, 1990). In our own research on science and mathematics education reform in Michigan (Spillane and Zeuli, 1997; Thompson, Zeuli, and Borman, 1997), we have found a few teachers who did seem to understand and work at the inner intent of the reforms, but a predominance of practice was remarkably similar to the patterns revealed in the California study several years earlier [1].

The authors contend that the essential point of the reforms that teachers find difficult to grasp is that the reform-based approach to mathematics learning requires students to think. While educators may verbally embrace the tenets of constructivism, the model of learning that pictures teacher as giver and student as receiver of knowledge is so pervasive that even those who actively pursue the principles of reform slip into the dominant model of teaching as knowledge transmission. Deep understanding of how students learn mathematics, complemented by deep understanding of the fundamental concepts and relationships of school mathematics, presents a daunting task for the mathematics reform agenda. Coupled with this challenge to change individual teachers' knowledge, skills, and beliefs about mathematics instruction is the equally challenging task of changing organizational knowledge, skills, and practice.

Conceptual Framework

A descriptive analysis of professional development practices in urban schools that have been successful in improving early reading performance through the assistance of Reading Specialists provides insight into key features needed for equivalent success in mathematics professional development. Creation of a threshold model to describe the interaction of individual and organizational features of professional learning provides a framework for planning professional development that is responsive to the complex nature of individual and organizational learning.

Using the threshold model as an organizer for our analysis, we focused on six urban high poverty elementary schools that differed markedly in their success in reducing the percentage of children identified as at risk for reading failure. The descriptive study examined whether there were differences in staff development practices in literacy acquisition in low SES schools that differed in achievement on the Virginia Phonological Awareness Literacy Screening (PALS) assessment [2]. We used a rubrics-based structured interview protocol that assessed individual and organizational growth features to identify school progress in using professional development as a means for reaching the elusive goal of becoming a professional learning community marked by value-added student achievement.

The six schools studied displayed real but subtle differences in the way that professional development experiences were incorporated in school instructional practices. All six schools served a high proportion of urban economically disadvantaged children. Three schools achieved a reduction in the percentage of children identified as at risk for reading failure of one standard deviation or more above the mean of 125 sample schools with parallel demographics. Three schools fell one standard deviation or more below the mean percentage in successful reduction of children identified as at risk. The most successful school reduced the percentage of children identified as at risk from 53% in the fall to 0% in the spring. The least successful school increased from 41% of children categorized as at risk in the fall to 70% identified as at risk in the spring (see Appendix A).

A number of factors probably explain this wide variation in success. We hypothesized that a complex mix of individual and organizational variables in professional learning, with concomitant variation in individual and organizational practice, might hold the key to unraveling the differences. As a foundation for our conceptual framework, we adopted the interactive school capacity model developed by M. Bruce King and Fred M. Newmann [3]. This model recognizes the interaction between individual and organizational behavior that we believe is fundamental to understanding the impact of professional development efforts. King and Newmann's school capacity model includes three components: teachers' knowledge, skills, and dispositions; professional community; and, program coherence. We hypothesized that successful implementation of these features in a kindergarten reading program would be marked by evidence of teachers collaborating to examine student work as the foundation for instructional decision making.

Our conceptual framework implies a threshold effect. Building on King and Newmann's construct of school capacity, the creation of a seven-dimension threshold model for understanding professional development permits the integration of a disparate body of research on individual and organizational knowledge. We suggest that adequate teacher knowledge applied in a coherent context of collective responsibility and evidenced by student-focused collaboration should result in improved student achievement. Drawing from literature on staff development and organizational culture, we created a series of interview questions and a rubrics-based system to test our model.

Expanding on the dimensions of school capacity identified by King and Newmann, Figure 1 displays the components of their school capacity model as grounded in professional development that incorporates the features of appropriate staff development identified in *Designing Effective Professional Development: Lessons from the Eisenhower Program* [4]. The components of the school capacity model are seen as creating conditions in which a school culture, characterized by Susan J. Rosenholtz's concept of "opportunity to learn," can flourish [5]. In the presence of these conditions, desired changes in individual practice and organizational practice may occur. Presence of the final dimension of staff development, "student-focused collaboration," is derived from the work of Judith Warren Little and is posited as being dependent on achievement of a threshold level of the supporting elements [6]. The seven dimensions illustrated in Figure 1 include:

- Dimension 1—Appropriate Staff Development includes six subdimensions: 1.1 Form, 1.2 Duration, 1.3 Collective Participation, 1.4 Content Focus, 1.5 Active Learning, and 1.6 Coherence (Prior Knowledge and Alignment)

- Dimension 2—Critical Attributes of Individual Knowledge includes six subdimensions: 2.1 Theory, 2.2 Demonstration, 2.3 Practice, 2.4 Peer Coaching, 2.5 Extended Learning, 2.6 Beliefs and Attitudes

- Dimension 3—Critical Attributes of Organizational Knowledge includes five subdimensions: 3.1 Shared Goals, 3.2 Collaboration and Collective Responsibility, 3.3 Reflective Inquiry, 3.4 Influence on Staff Development, 3.5 Program Coherence

- Dimension 4—Opportunity to Learn

- Dimension 5—Individual Practice

- Dimension 6—Organizational Practice

- Dimension 7—Student-Focused Collaboration

The third component of our conceptual framework asserts that attainment of a professional community with sufficient capacity to nurture student achievement is linked to the *interaction* of individual and organizational capacity. That interaction is evidenced by the instructional planning practice of student-focused collaboration. Student-focused collaboration is posited as a *reciprocal* contributor to schoolwide conditions for student achievement. When teacher groups accurately examine student work as a source of data to focus instructional planning, both individual and collective professional knowledge blossom and increased student achievement may result.

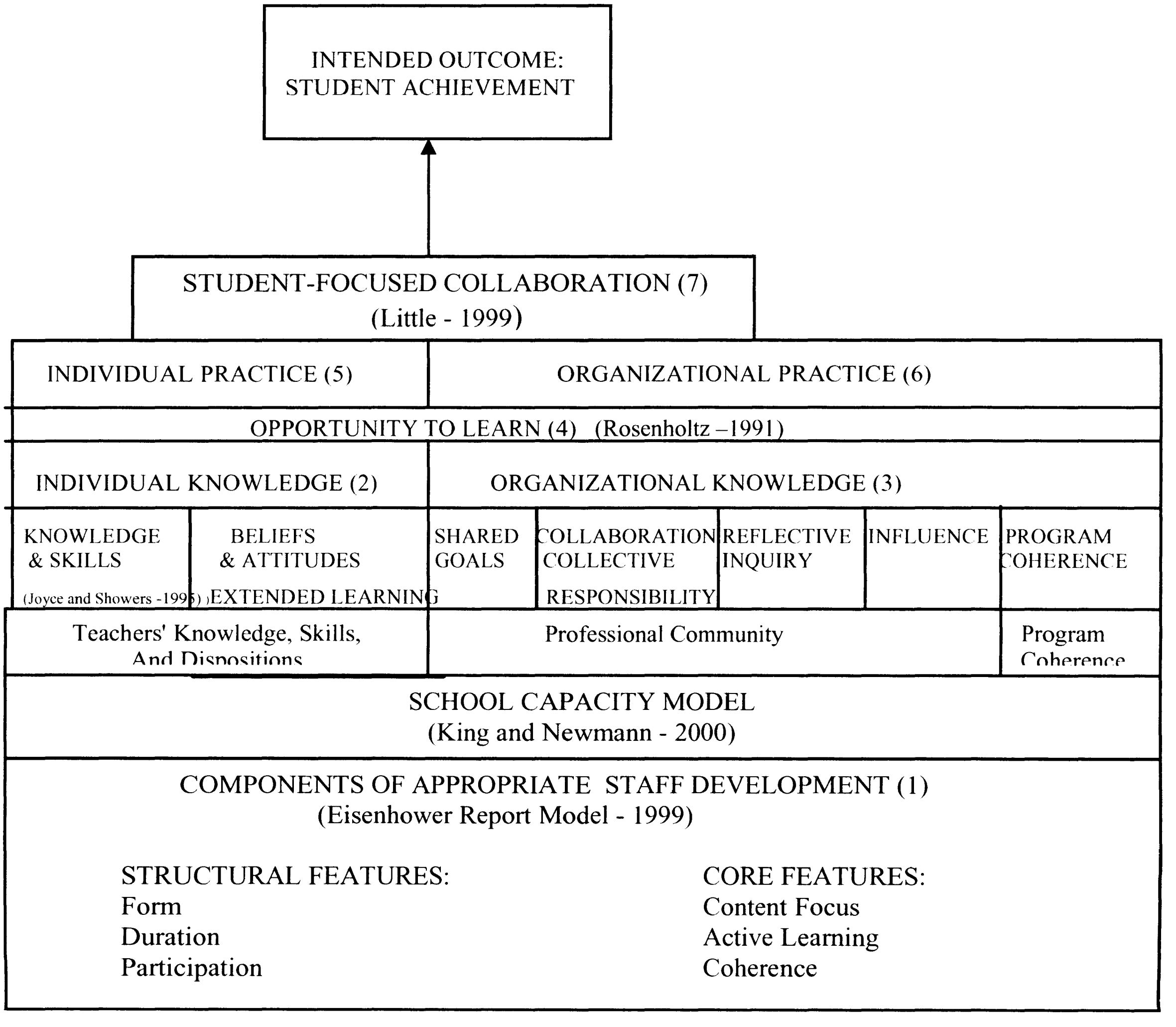

Figure 1: Professional Development—A foundation for School improvement: a threshold model.

The theory-based assertion is that development of sufficient capacity at each level functions as a threshold for acquisition of the next higher level component.

Parallel Case Example in Kindergarten Reading Professional Development

A sample of Virginia schools with a free or reduced lunch eligibility percentage of 58% or higher was drawn by examination of pre- and post-test scores of individual children from each qualifying school. The sample included individual student data from all schools that participated in the 1999-2000 PALS assessment and that had data for sixty or more children who were both pre-tested and post-tested. The final sample included 125 schools serving 8,355 children who were both pre-tested and post-tested. A random sample was taken of three schools in the group that scored one standard deviation or more above mean reduction in percentage of children identified as at risk and of three schools that scored one standard deviation or more below the mean.

Artifact and interview data were collected and analyzed for each school. As part of the analysis, we focused on data that reflected the level of student-focused collaboration. The term "student-focused collaboration" was defined as specific events that provide evidence of its presence in the kindergarten literacy setting. These included: 1) shared discussion of student responses in oral activities and written work samples;
2) student-focused team meeting minutes; 3) shared planning for professional learning about literacy; and, 4) shared planning for instruction that included discussion of strategies aimed at incorporation of designated components of literacy instruction. In our data analysis, student-focused collaboration was coded under the categories for **3.2 Collaboration and Collective Responsibility**, **3.3 Reflective Inquiry**, and **3.4 Influence on Professional Development**. Our definition of professional development included evidence of related ongoing efforts targeted to the same goal and included team meetings and other collaborative job-embedded work as a form of professional development.

There were striking differences between the higher and lower achieving schools across the eighteen reporting categories that were numerically coded. The differences included both individual and organizational features, and reflected differences in the role and degree of participation of Reading Specialists in the daily life of each kindergarten team. Appendix B illustrates the tallied data across study categories for the higher and lower achieving schools. Features of these practices in the higher achieving schools may productively inform mathematics leadership efforts to design effective roles for PreK-8 Mathematics Specialists.

Analysis and Implications of these Findings for Mathematics Staff Development and the Role of PreK-8 Mathematics Specialists

Among the group of higher performing schools studied, School Two consistently displayed professional learning behaviors that supported continuous improvement in student achievement (see Appendix C). Examination of this school's status on selected professional development variables has implications for mathematics staff development practice. The data also support our hypothesis that a threshold effect takes place in building professional learning communities. When an adequate level of individual knowledge is complemented by organizational skill and collective knowledge, the preconditions for the practice of student-focused collaboration are met. Specifically, formal staff development activities were augmented in this school by job-embedded learning opportunities. These took the form of team meetings focused on literacy practices in which the Reading Specialists played an active role as peers and as knowledge resources. Further activities of the Reading Specialists included co-teaching and coaching events in which the Specialist served as either model or observer. If Mathematics Specialists are deployed in parallel roles, then similar gains in student mathematics achievement may be expected.

Our framework identifies six categories in Dimension 1 derived from features of appropriate professional development identified in *Designing Effective Professional Development: Lessons from the Eisenhower Program* [4]. **Dimension 1.1 Form** distinguishes between traditional and reform delivery models. *Reform* activities in School Two included teacher participation in study groups, referred to as guided professional book talks, and regular use of Internet resources for individual and group exploration. *Traditional* delivery model training included three phases. The first phase, awareness level training, was provided at the district level. It was built on by phase two training, described as exploration and extension/management. This level included both district and job-embedded training. Third phase training was described as refinement/reflection and incorporated both district and job-embedded elements. The principal of School Two had carefully correlated district professional development with in-school follow-up training that explored each topic at grade specific levels. A key element of the delivery system was assignment to each school of a Reading Specialist whose sole responsibility was grade-level and classroom presentation of information, follow-up, and support of professional development work. In this school setting, this initiative took the form of weekly staff development team meetings with the entire kindergarten staff, as well as individual classroom follow-up in the form of modeling, observation, and coaching.

It appears that the *coherence* among these efforts and the coordination of efforts by the principal and the Reading Specialist who was available on a daily basis contributed to the success of the kindergarten team. Clear assignment of role responsibilities, provision of adequate time for specialist assistance, and coherence among district, building, and grade level staff development activities are markers for success that mathematics program planners might profitably emulate.

Dimension 1.2 Duration addresses the total number of content hours as well as the span of time over which training is delivered. The school's intense immersion model delivered 76.75 hours of direct and job-embedded instruction in one year. Initial direct training sponsored by the school division was followed by monthly visits by the same outside training provider. Building-based meetings included an annual total of 24 hours of quarterly daylong meetings that focused on development of literature-based thematic units to support the skills continuum of the division training. The Reading Specialist delivered an additional 20.25 hours of follow-up training to the division-sponsored training. Staff development kindergarten team meetings attended by the Reading Specialist and the Title I Literacy Teacher provided another 22.5 hours for discussion and application of the content provided in district and building level sessions. Throughout this period, the Title I Teacher taught small groups of children in each classroom during literacy instruction time, and informally modeled techniques that classroom teachers saw as effective and began to adopt. Implications for effective reform in mathematics include sufficient duration for professional development activities, both in direct instruction and in job-embedded modes. Mathematics Specialists can play a critical role in helping teachers apply new insights to specific classroom situations.

Dimensions 1.3 Collective Participation, **1.4 Content Focus**, **1.5 Active Learning**, and **1.6 Coherence** (connection to prior knowledge and alignment with other school efforts) were also addressed effectively in this professional development effort. School scheduling provided common team planning time daily for the kindergarten staff. The principal, who frequently attended these meetings, mandated the use of this time on Tuesdays for common lesson planning and on Thursdays for professional development. During the 1999-2000 school year, the Reading

Specialist took the lead in establishing topics and providing content materials. By the 2001-2002 school year, the kindergarten team had assumed major responsibility for organizing the questions examined at each weekly professional development team meeting, and submitted topics to their grade chair who circulated agenda items before the meeting. Over time, a gradually emerging team structure evolved in which the Reading Specialist and the Title I Reading Teacher assumed roles as valued peers and readily available information resources within a high functioning grade-level team. In 1994 as a foundation for development of team learning, the principal provided direct instruction in shared decision making. By the 1999-2000 school year, the school was engaged in its sixth year of working in this way. Implications for planning job-embedded mathematics professional learning initiatives and the use of Mathematics Specialists include attention to prerequisite development of team decision-making skills and provision of a layered, ongoing set of knowledge growth strategies.

Dimension 2 of our framework incorporates professional development efforts that attend to *individual* knowledge and belief systems. **Dimensions 2.1** through **2.5** incorporate components of the individual training model developed and validated by Bruce Joyce and Beverly Showers [7]. School Two was the only school studied that displayed consistent incorporation of the features of **2.1 Theory**, **2.2 Demonstration**, and **2.3 Practice** in formal and job-embedded professional development. Although teachers did not immediately respond affirmatively to questions about incorporation of theory in their training, they unanimously agreed that their training consistently included a number of theory-based components: attention to how children learn to read, to stages of literacy development, and to learning to diagnose features of print in children's work samples. Joyce and Showers make a compelling case for the incorporation of discipline specific theory in training efforts when they define presentation of theory as:

> An exploration of theory through discussion, readings, lecture, etc; this is necessary for an understanding of the rationale behind the skill or strategy and the principles that govern its use. Study of theory facilitates skills acquisition by increasing one's discrimination of the demonstrations, by providing a mental image to guide practice and clarify feedback, and by promoting the attainment of executive control [7].

Implications for mathematics professional development include incorporating attention to theory accompanied by systematic bridging of the theoretical underpinnings of instruction and of how students learn mathematics, to application in teachers' daily practice. In their work in cognitively guided instruction, Carpenter, Fennema, and Peterson have contributed important schema for analyzing children's knowledge of word problems [8]. When the researchers' knowledge is translated into grids with examples that help teachers analyze the tasks involved in problem solving, the presentation of theory becomes a valued part of the professional development experience [8].

Dimension 2.4 Peer Coaching took an alternate form at School Two. Coaching was an important part of practice as provided by the Reading Specialist. Informal peer observation and follow-up conversation also occurred between the Title I Specialist who taught daily in each classroom and the classroom teacher who was simultaneously working with another reading group. **Dimension 2.5 Extended Learning** addresses teachers' opportunities to attend professional development opportunities outside the school setting. This opportunity was available at both the higher and lower achieving schools and the school scores among the group of six schools were similar. School Two, however, displayed a critical difference. At School Two, there was an understood condition that attendance at a sponsored conference carried an obligation to report back to one's peers upon return. This practice not only increased access to knowledge for the entire kindergarten group, but also provided the conference attendee an opportunity to assimilate the knowledge in a manner that made it possible to present it to others. Adoption of this practice in mathematics improvement efforts may be beneficial.

Dimension 2.6 Beliefs and Attitudes about Teaching is based on the work of S.J. Rosenholtz in which she distinguishes between individuals who see teaching as mastery of a prescribed set of skills and those who view it as a lifelong cumulative and developmental process [5]. Teachers who view teaching as complex and understand their own development as cumulative are typically more open to continuing efforts to improve practice and more comfortable discussing the dilemmas of practice. Attention to individual beliefs and attitudes, as well as their impact on school culture, is an essential feature to consider when planning staff development efforts and an arena in which the interpersonal skills of the Mathematics Specialist will be critical.

Dimension 3 includes five critical attributes of *organizational* culture derived from the work of King and Newmann [3]. School Two outperformed its peer schools on most of these attributes. **Dimension 3.1 Shared Goals** was measured by a review of artifacts, as well as interviews with the principal, Reading Specialists, and kindergarten teachers. Conscious effort to bring teachers and administrators together frequently to discuss their work enlivened the generic goal of high student performance. The principal's stated goal was "consistency between teachers, between teachers on a grade level, and across grade levels." Teachers identified their greatest strength as learning and working together. "We try to do everything together. We say, bring your ideas." Implications for the role of the Mathematics Specialist include working with building administrators to provide school structures that facilitate teachers working and learning together. The teacher isolation typical of elementary schools does not support the kind of group effort needed to bring about consistent improvement in student achievement. Attempts to improve the performance of teachers who attend courses or programs in isolation may only add to the existing breaches in many schools between the "superstars" and the remainder of the staff. School division-level planners might do well to send school teams rather than pick one representative from each school in the division to attend workshops. The common practice of sending a single representative from each school is sometimes justified as a means of equitable resource distribution and sometimes reflects a scattershot attempt to create train the trainer models without providing resources needed to implement and maintain changes in practice.

Dimensions 3.2 Collaboration and Collective Responsibility, **3.3 Reflective Inquiry**, and **3.4 Influence on Professional Development** were examined collectively as a means for assessing school success in bringing about the practice of student-focused collaboration. The principal's leadership at School Two in articulating her support for each of these attributes apparently strengthened their day-to-day implementation. As described by Newmann, King, and Rigdon, a key feature of collaboration and collective responsibility is the willingness of teachers to assume collective responsibility for the success or failure of their students rather than to blame factors external to their classroom or to the school [9]. Where collective responsibility is evident, teachers work in a solution finding mode. If a large number of students are failing to master requisite skills, teachers first examine their instruction and assessment to identify needed changes. When all staff members have a stake in the success of every student, the likelihood of identifying needed changes in school infrastructure, curriculum, instruction, or assessment increases.

For schools starting mathematics improvement efforts, it makes sense to include a multi-grade cross section of the teaching staff in a curriculum audit, followed by analysis of current practices in instruction and assessment. This type of effort provides a foundation for developing collective responsibility by inculcating the practices of lesson study and shared diagnosis of student work. When a resident Mathematics Specialist initiates these efforts with the support of the building administration, the process should gain the emphasis and the staffing it needs to produce useful results.

Practice of **Dimension 3.3 Reflective Inquiry** is central to the effort of a school that strives to become a learning community. At School Two, the principal was able to give examples of kindergarten group discussion about literacy, citing specific children about whom the group was concerned and the strategies they had developed for addressing those concerns. The teacher group mentioned analysis of children's writing samples, shared planning for skills instruction, and comparison of children's progress on Breakthrough to Literacy computer instruction as examples of specific ways they used the children's work and specific skill acquisition to focus their conversation.

For mathematics instruction, parallel examples of reflective inquiry might include use of students' oral and written work samples for teachers' analysis of what students understand as well as their points of confusion, use of lesson study, and use of diagnostic interviews.

Dimension 3.4 Influence taps the degree to which teachers have input in defining professional learning goals and the opportunity to designate the content of professional development. The city plan for elementary reading included a concurrent central and school focus for staff development. The principal cited teacher involvement in planning weekly team meetings as evidence of influence on staff development. The grade group described their involvement in planning team meetings, but did not identify this activity as staff development. Although this school exhibited a well-integrated model of job-embedded staff development, the teachers apparently did not see their contribution to the effort as a "staff development" activity. They cited their input role in requesting in-service sessions, but seemed to see themselves as recipients of knowledge rather than as contributors to knowledge. The old definition of staff development as "something done to you" seemed to linger even in an environment characterized by lively commitment to professional learning.

For staff development efforts in mathematics, it may be helpful to define explicitly the contributions of both formal and job-embedded components. If teachers understand that their work in teams contributes to knowledge about how children learn, they may gradually adopt a more holistic and positive attitude toward professional learning that replaces the stereotypes associated with "staff development."

Dimension 3.5 Program Coherence addresses ongoing professional communication among and between grades. Kindergarten teachers at School Two had developed remarkably fluid and beneficial communication among themselves. Their communication about literacy instruction with teachers in other grades was far more scattered and haphazard. Both the teacher group and the principal expressed a desire to foster more communication and consistency across grade levels. The school schedule was structured to provide daily access for each grade level-team. This goal precluded the possibility of cross grade-level meetings during the school day. The principal scheduled occasional early morning cross grade-level meetings for professional development, used memos to communicate administrative information, and limited after school meetings as much as possible. The principal indicated that the schoolwide, shared decision making team was trying to address this need. An effort to create curriculum coherence across grades was evident in cross grade-level curriculum guides and multi-grade instructional materials.

As building-level Mathematics Specialists work with principals and teachers to plan a long-term professional learning endeavor, it will be helpful to examine allocation of professional time and decide in advance how to prioritize time resources between the conflicting demands for grade level and cross grade-level professional development.

Dimension 4 Opportunity to Learn is derived from the work of S.J. Rosenholtz. In schools that Rosenholtz describes as *learning enriched*, teachers support the need for continuous learning. Their view of schooling as a non-routine technical culture demands that they cannot use a formulaic approach, but must adjust to specific situational demands. Curriculum and learning are seen as complex and the assistance of others in seeking solutions becomes critical [5]. In response to the question, Where do your new teaching ideas come from? 92% of teachers from learning-enriched schools cited other teachers as the source of their new ideas, with 72% of this group reporting a second source as their own problem solving and creativity [5]. Teachers in School Two consistently reported turning to each other, and using their own creativity and reflection about their work as ways of improving instruction. They also cited avoiding conversations focused on venting frustration or placing blame on external factors.

Mathematics Specialists can play an important role in grade-level team learning by modeling openness to divergent solutions and ease with acknowledging the complex nature of supporting children's mathematical thinking. Modeling behavior that reflects these key elements of mathematics instruction should also support creation of a climate in which teachers feel safe discussing the perplexities they encounter in lesson planning, instruction, and assessment.

Dimension 7 Student Focused Collaboration functions as a subtype that extends King and Newmann's definition of professional community [3]. In this study, it was defined as building on achievement of a threshold level of individual and organizational knowledge and practice, and was characterized by exhibition in daily practice of *collaboration*, *collective responsibility*, *reflective inquiry*, and *influence* on the content of professional learning (see Figure 1).

In a grade-level team that optimizes its capacity to deliver effective mathematics instruction, all of these features may be expected to occur. Examples of this behavior in the mathematics setting might include group lesson study, analysis of diagnostic interviews with students, group analysis of student written work, and dialogues about classroom events that yielded puzzlement or enlightenment. Consistent presence of these behaviors reflects achievement of a culture characterized by ongoing professional learning.

Comparative Analysis of School Performance in Reading Achievement

In the study of kindergarten reading achievement, the higher scoring group of schools outperformed the lower scoring group on nineteen out of 21 components of the dimensions of staff development model. Comparison between the higher and lower scoring schools revealed the following key findings.

- Access — In the higher scoring schools, teachers made more regular use of the professional knowledge resource personnel available in the building. Availability of skilled Reading Specialists who participated actively in classroom life made information and strategy searches much easier. Teachers appeared to be more confident in articulating perplexity about practice or the need for information.

- Intentional Knowledge Growth — In the higher scoring schools, teachers took ownership of available planning time to address questions of professional interest and sought research-based solutions to problems of practice. This included use of student work samples as a focus for reflective inquiry.

- Best Practice-Based Planning — In the higher scoring schools, teachers used available lesson planning time to develop instruction that reflected research-based knowledge about reading development.

- Integration of Knowledge — In the higher scoring schools, teachers and administrators developed a shared conceptual framework to support individuals in their integration of new information and suggested practices. This included opportunities for demonstration, practice, and coaching in a non-evaluative setting.

- Experimentation — In the higher scoring schools, teachers received peer support for experimentation with new strategies, but strategies were weighed against information about appropriate practice for varying levels of reading development.

- Eisenhower Study Model — In the higher scoring schools, formal staff development initiatives included greater incorporation of practices identified by the Eisenhower study: longer duration, collective participation, content focus, active learning, attention to prior knowledge, and alignment with state standards [4].

- Joyce and Showers Model — In the higher scoring schools, formal staff development initiatives demonstrated greater incorporation of the training components of theory, demonstration, practice, and coaching [7].

Recommendations for Practice—Becoming a Professional Learning Community

If schools are to be successful in nurturing professional learning, they must discard the common view of staff development as a series of events in which teachers act as passive recipients of knowledge. The notion of continuous intentional professional learning is based on a constructivist view of teachers' attempts to make sense of their practice by continual exploration of that practice in job-embedded settings. Courses, conferences, and workshops can contribute, but their impact will only be as great as the individual school's skills in helping its faculty integrate new information into the school's continuing quest for improved practice. The authors of *What Matters Most: Teaching for_America's Future* lamented the common professional development experience of teachers by noting that:

> While teachers are being asked to engage their own students in active learning, problem solving, and inquiry, they rarely experience this kind of learning themselves [10].

Job-embedded and formal initiatives for adults aimed at increasing professional knowledge and supporting development of intentional learning should attend to principles of instruction suggested by research and corroborated by the comments of teachers and principals interviewed in this study. Drawing from the literature as validated by this study, the following suggestions for professional development practice in both mathematics and reading are proposed:

Job-Embedded Practice

- Work to replace the idea of staff development as in-service workshops with a broader definition of professional learning.

- Create structures for a professional community that encourages access among teachers to the broadest possible resource knowledge base by clarifying the role of specialists and other resource personnel.

- Create structures for team planning that clarify roles, goals, and procedures for intentional professional knowledge growth, reflective inquiry, and collaborative planning.

- Establish a shared working conceptual framework for the principles and content of programs that is specific enough to guide teams in making decisions about instructional content and practices.

- Establish procedures to institutionalize the integration of new knowledge and help individuals find solutions to questions that arise from disparate information sources.

- Encourage a culture of experimentation with new strategies that routinely weighs proposed activities against best practice research.

Formal Professional Knowledge Initiatives

- Establish a specific connection between the content of study and its usefulness to the teacher as a way of understanding children's learning and planning to enhance it.

- Provide information that contains specific examples, including work samples, classroom observation, and video sequences, of how the suggested theory relates to practice and informs instructional decision making.

- Plan for practice and feedback of suggested skills in the workshop and in a supportive environment within the school. This implies active participation of building administrators in the ongoing learning of teachers both by attendance at training sessions and by establishment of procedures to support and facilitate practice and debriefing.

- Recognize that incorporating new strategies in professional repertoire takes repeated practice and refinement. Provide ongoing coaching and support.

- Provide frequent opportunities for teachers to engage each other in substantive, reflective conversations about their practice in a supportive setting.

- Provide the materials needed to inculcate the practice. Recognize, budget for, and monitor the need to update supplies and equipment.

By their knowledge, accessibility, and skill in working with both adults and children, well-prepared school-based Mathematics Specialists can support improvement of children's learning. The reforms envisioned for mathematics education demand several major shifts in understanding. *Lenses on Learning*, a National Science Foundation-funded professional development program for school administrators, identifies several key goals for school level improvement [11]. Teachers' acquisition of deep content knowledge, understanding of how children learn mathematics, and ability to facilitate discourse-based instruction are central objectives. Achieving each of these goals will require formal professional development initiatives that must be accompanied by the ongoing support in tackling questions about content and practice that school-based Mathematics Specialists will be able to provide. In our study of staff development in kindergarten reading, we learned that access to and integration of research-based knowledge was critical for success. Mathematics Specialists can help teams of teachers develop a shared conceptual understanding of effective practice. That knowledge base will guide teachers as they explore and refine their assumptions and teaching behavior. Nothing less than exceptional professional development instruction accompanied by intense ongoing support is needed. Thompson and Zeuli capture the magnitude of the task:

> The essential point—the inner intent—that seems so seldom grasped even by teachers eager to embrace the current reforms is that in order to learn the sorts of things envisioned by reformers, students must think. In fact, such learning is almost exclusively a product or by-product of thinking. By "think," we mean that students must actively try to solve problems, resolve dissonances between the way they initially understand a phenomenon and new evidence that challenges that understanding, put collections of facts or observations together into patterns, make and test conjectures, and build lines of reasoning about why claims are or are not true. Such thinking is generative. It literally creates understanding in the mind of the thinker [1].

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Appendix A
Fall and Spring Performance of Six Schools on Phonological Awareness Literacy Screening in 1999-2000

	School Number					
Data	#1	#2	#3	#4	#5	#6
% Pre-/Post-test	86	69	87	89	93	92
# Pre-/Post-test	78	114	68	57	51	91
# Failing to Meet Fall Criterion Score	42	42	26	5	22	37
% Failing to Meet Fall Criterion Score	53.85	36.84	38.24	8.77	43.14	40.66
# Failing to Meet Spring Criterion Score	0	9	7	12	31	64
% Failing to Meet Spring Criterion Score	0	7.89	10.29	21.05	60.78	70.33
Reduction in Percentage Failing to Meet Criterion Score from Fall Testing to Spring Testing	+53.85	+28.95	+27.95	-12.28	-17.6	-29.67

Sample Schools (n=125) Mean % Pre-/Post-test = 89.25, S.D. = 6.09

Sample Schools (n=125) Reduction in Percentage Failing to Meet Criterion Score from Fall Testing to Spring Testing: Mean Change = 9.36, S.D. = 12.54

Appendix B
Comparison of Three Higher and Three Lower Scoring Study Schools on *Dimension 7 Student-Focused Collaboration*, and on Contributing Dimensions

Data Unit	Three Higher Scoring Schools	Three Lower Scoring Schools
Dimension 7 — Student-Focused Collaboration: Mean of Summed Scores for 3.2 – Collaboration and Collective Responsibility, 3.3 – Reflective Inquiry, and 3.4 – Influence on Professional Development (00.00-130.00)	75.33	44.67
Mean of Summed Scores For Dimension 4 — Opportunity to Learn (00.00–26.00)	21.33	10.33
Mean of Other Mean Scores By Dimension Number:		
1.2 Duration (1.00-3.00)	2.78	1.89
1.3 Collective Participation (1.00-4.00)	3.00	1.89
1.4 Content Focus (1.00-3.00)	2.25	1.08
1.5 Active Learning (1.00-3.00)	2.17	1.50
1.6 Coherence [Prior Knowledge and Alignment] (1.00-3.00)	1.52	1.00
2.1 Theory (0.00-2.00)	1.11	0.00
2.2 Demonstration (0.00-2.00)	1.62	0.17
2.3 Practice (0.00-2.00)	1.00	0.17
2.4 Peer Coaching (1.00-2.00)	1.39	0.67
2.5 Extended Learning (0.00-1.00)	0.80	0.89
2.6 Beliefs and Attitudes (1.00-2.00)	2.00	1.67
3.1 Shared Goals (0.00-1.00)	0.73	0.38
3.5 Program Coherence [Professional Communication] (1.00-3.00)	2.39	1.67
5 Individual Practice (0.00-1.00)	0.75	0.74

Note: Numbers in parentheses indicate the possible score range for each item.

Appendix C

Dimensions of Staff Development — Individual School Profile — School Two

Dimension	Sum	Mean	Summed Dimensions
1. Appropriate Staff Development			
1.1 Form	Mixed		
1.2 Duration	8	2.67	
1.3 Participation	9	3.0	
1.4 Content Focus	18	3.0	
1.5 Active Learning	8	2.67	
1.6 Coherence (Prior Knowledge, Content Alignment)	26	2.36	
2. Individual Knowledge			
2.1 Presentation of Theory	6	2.0	
2.2 Demonstration	6	2.0	
2.3 Practice	2	2.0	
2.4 Peer Coaching	6	1.5	
2.5 Extended Learning	4	0.8	
2.6 Beliefs and Attitudes	4	2.0	
3. Organizational Knowledge			
3.1 Shared Goals	6	0.75	
3.2 Collaboration and Collective Responsibility	60		Summed categories for Dimension 7 include 3.2+3.3+3.4=92
3.3 Reflective Inquiry	22		
3.4 Influence (Content of Staff Development)	10		
3.5 Program Coherence	9	2.25	
4. Opportunity to Learn			
4 Opportunity to Learn	19		
5. Individual Practice			
5 Individual Practice	10	0.83	
6. Organizational Practice			
6 Organizational Practice	Narrative		
7. Student-Focused Collaboration	92	**See Appendix B for comparative scores.**	