Lessons Learned in the Implementation of the TRIAD Scale-Up Model

Teaching Early Mathematics with Trajectories and Technologies

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Although the successes of research-based, visionary educational practices have been documented, equally recognized is the failure of these practices to be implemented at a scale that affects more than a trivial portion of children. Further, there may be no more challenging educational and theoretical issue than scaling up educational programs across a large number of diverse populations and contexts in the early childhood system in the United States, avoiding the dilution and pollution that usually plagues such efforts to achieve broad success (Clements & Sarama, 2011). In this chapter, we describe a model of scale-up at the school district level and its initial evaluation. Although our intent is that the model should apply to all subject matter domains and grade levels, any evaluation must involve a specific instantiation. Our evaluations have focused on early childhood mathematics. Therefore, we begin with background information on the need for models of scale-up, especially in early childhood education, as well as a consideration of the particular needs in mathematics education. Next, we introduce the theoretical framework, the model we developed, and the research corpus on which they were based. We then summarize the empirical evaluations we have conducted of this model. In the final section, we summarize what we have learned and describe implications and challenges for the field.

Background

Education needs generalizable models to scale up evidence-based practices and programs and longitudinal research evaluating the persistence of the effect of their implementations (Borman, 2007; Cuban & Usdan, 2003). Research-based educational practices that make practically and statistically significant differences in the development and learning of children have been documented.
(e.g., Clements & Sarama, 2011; Clements, Sarama, Spitler, Lange, & Wolfe, 2011; McGill-Franzen, 2010). Unfortunately, the "deep, systemic incapacity of U.S. schools, and the practitioners who work in them, to develop, incorporate, and extend new ideas about teaching and learning in anything but a small fraction of schools and classrooms" (Elmore, 1996a, p. 1) has also been documented (Berends, Kirby, Naftel, & McKelvey, 2001). How can we start to understand and solve this problem? Our story begins as we consider the careful planning that scale implementation involves. We then move to discuss the particular challenges.

At the simplest level, taking promising interventions to scale means implementing them successfully in many settings. To do so successfully, however, is to confront the complexity of such an enterprise. For example, with scale-up there is an increase not only in the number of students and teachers involved in the enterprise but also in both the number of categories of stakeholders and the number of different and often conflicting perspectives they hold. Therefore, we define scale-up as the instantiation of an educational intervention in varied settings with diverse populations, addressing the needs of multiple sociopolitical stakeholders, so as to achieve 1) satisfactory fidelity of implementation and, as a result, 2) the intervention's goals for over 90% of the children who could benefit from the intervention and ultimately 3) eventual transfer of the intervention to local ownership, sustainability, persistence of effects, and continuing diffusion. (This is based on a school-district adaptation and implementation; across wider areas and organizations, such as a state, a goal of 60% would be satisfactory.)

That definition alone could induce trepidation: It is a daunting task. Before we confront additional challenges, we will discuss some of this definition's components. First, consider the complexity of the perspectives, needs, and desires of the different categories of stakeholders within a school district—parents, various community groups, the professional teaching community, educational leadership in early childhood and in subject-matter content (often these are distinct groups), and higher level administrators such as school principals and superintendents (or child care directors), among others. To bring such diverse groups together to support an intervention is a challenging task indeed. Achieving an adequate fidelity of implementation of any intervention presents myriad challenges, such as sufficiency of materials and technology, professional development, in-class support, and so forth. Each of these challenges requires both financial and social capital. An example of social capital is the essential support of school leaders, which drives improvements in all others components of the system (Bryk, Sebring, Allensworth, Suppescu, & Easton, 2010).

Turning to another component of the definition, interventions are not useful if they do not live on after the initial thrust for the implementation. We categorize lasting effectiveness as sustainability or persistence with the potential for diffusion. Sustainability means the length of time an innovation continues to be implemented with fidelity. Persistence means continuation of the effects of an intervention on individual children's trajectories of learning. Diffusion is the process through which an intervention gets communicated over time among the members of a social system, that is, the process by which interventions get spread more widely beyond those initially exposed to it (Dearing, Maibach, & Buller, 2006). Diffusion may or may not be a direct goal, but can be important to other educators and students and
to sustainability, because adoptions in other locales may help motivate continuing support within the intervention site.

As stated, a scale-up project has to do a lot to succeed. However, there are additional challenges for those in the field of early childhood and yet another set of challenges for those focused on mathematics education. Early childhood, especially before kindergarten, includes settings and organizational structures that vary far more than do those at any other age level (National Research Council, 2009). The workforce in those settings, their backgrounds, and their professional education are similarly diverse. Research suggests that the most critical feature of a high-quality educational environment is a knowledgeable and responsive adult; it also suggests that high-quality professional development is essential to innovation (Darling-Hammond, 1997; Ferguson, 1991; National Research Council, 2001, 2009; Sarama & DiBiase, 2004; Schoen, Cebulla, Finn, & Fi, 2003). Because of this, scaling up professional development has special challenges in early childhood contexts, including the diverse workforce, the equally diverse knowledge of teachers, and, for interventions such as ours, many teachers’ resistance to or rejection of “academics.” We must meet that challenge, however, because long-range benefits to children are greatest for interventions in that period (Clements & Sarama, 2009).

The learning of mathematics also presents special challenges. The importance of mathematics is well known, especially in a global economy with the vast majority of jobs requiring more sophisticated skills than in the past (Doig, McCrae, & Rowe, 2003). However, U.S. students do not perform well compared to students from many other nations, as early as kindergarten (Stigler, Lee, & Stevenson, 1990) and even the preschool years (Yuzawa, Bart, Kinne, Sukemune, & Kataoka, 1999). Such achievement gaps are most pronounced in U.S. children from low-resource communities (Siegler, 1993). This is especially worrisome because early knowledge strongly affects later success in mathematics (National Mathematics Advisory Panel, 2008).

Thus, we need to improve the basic academic mathematical concepts, skills, and motivation of low-achieving children early in their school career (Claessens, Duncan, & Engel, 2007). Although this can be achieved by providing high-quality experiences in early mathematics (Doig et al., 2003; Thomson, Rowe, Underwood, & Peck, 2005), few early childhood programs or settings do so (National Research Council, 2009).

In summary, scaling up high-quality mathematics education within early childhood settings holds particular challenges that range from the logistical (e.g., all-day professional development may take teachers away from emotionally dependent children) to the philosophical and motivational (why “push down” math onto young children?) to the practical (many teachers lack knowledge of the content of mathematics as well as its learning and teaching). A model of scale-up must address these challenges if it is to support a high-quality implementation.

The Implementation Key

Implementation of an intervention that has documented efficacy (i.e., has been shown in rigorous studies to be effective at least on a small scale) is the sine qua non of a successful scale-up. Without high-fidelity implementation, few positive results can be realized. One cannot even know if the intervention could have been effective
or not. Lack of information about the fidelity of implementation is a key missing piece of the scale-up research puzzle (Borman, Hewes, Overman, & Brown, 2003). Indeed, just having certain characteristics such as a specific curriculum, professional development, or goals does not appear to matter—the implementation of these characteristics is what matters.

Appreciation of these research results is one reason educators are moving from “let it happen” to “help it happen” and, increasingly, to “make it happen” strategies of implementation (Greenhalgh, Robert, MacFarlane, Bate, & Kyriakidou, 2004, p. 593). That is, a let-it-happen view of natural emergence of the implementation has given way to helping the implementation with negotiated social supports that enable the implementation. More often, even stronger support is provided by scientific, planned systems that are managed and monitored. The following two sections describe 1) the theoretical framework we developed for our research and development work on implementation and wider scale-up and 2) the model we derived from it to make it happen.

Framework

The overarching theoretical framework for our research and the development of a scale-up model is an elaboration of the Network of Influences framework (Sarama, Clements, & Henry, 1998), describing our theory of the relationships and influences that must be attended to achieve successful scale-up. Most are important for any intervention; however, in small interventions, components can often be compensatory or even ignored. In scale-up efforts, we posit that many are critical.

We consider successful implementation of an intervention at scale to involve multiple coordinated efforts to introduce, implement, and maintain the integrity of the vision and practices of an innovation through increasingly numerous and complex socially mediated filters. The depiction of the Network of Influences framework in Figure 9.1 illustrates the hypothesized influences of context and implementation variables on outcomes such as teacher knowledge, child achievement, and sustainability. The “Follow Though” model (U), at bottom right in the figure, most relevant to this study, is simply a microcosm of the framework.

In Figure 9.1, contextual variables, in dotted ovals, include contexts that are situations not determined by the model, such as school (A–D), teacher (E), and child (F–H) factors. As an example of these variables in the framework, child socioeconomic status (SES; G) impacts children’s initial knowledge (H), which influences their achievement (R)—an outcome variable indicated by the solid rectangle. Implementation variables are depicted in solid ovals. These are features that the project can encourage and support, but cannot control absolutely. For example, heavy arrows from professional development (J) to teacher knowledge (N) to implementation fidelity (O) to child achievement (R) indicate the strong effects in that path. Support from coaches (L) also has a strong effect on teachers’ knowledge and practice, while other factors (J, K, M) are influential, but only to a moderate degree (small effects are not depicted).

The following subsections describe our elaborations of the Network of Influences framework, including the major stakeholders (e.g., administrators, teachers, children and their families) and their relationships and interactions.
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Educational Interactions

A successful model for scale-up in education must move beyond simply adopting a new curriculum or teaching model—a common but unsuccessful intervention. Instead, it must scale up all the supports necessary to positively affect the “interactions among teachers and children around educational material” (Ball & Cohen, 1999, p. 3). This strategy creates extensive opportunities for teachers to focus on subject matter, goals, and children’s thinking and learning, which improves teachers’ knowledge of subject matter, teaching, and learning and increases child learning and development (Ball & Cohen, 1999; Cohen, 1996, p. 98; Schoen et al., 2003; Sowder, 2007).

Administrators and Other School Leaders

Principal leadership (Figure 9.1, K) is strongly related to levels of implementation and effectiveness (Berends et al., 2001; Bodilly, 1998; Bryk et al., 2010; Fullan, 1992; Heck, Weiss, Boyd, & Howard, 2002; Kaser, Bourexis, Loucks-Horsley, & Raizen, 1999; Klingner, Ahwee, Pilonieta, & Menendez, 2003). Effective administrators provide the time for teachers to experiment, discuss, and, in general, construct their own meanings of the innovation. They communicate continuing commitment (Figure 9.1, I), not just in verbal form but also in other ways, such as resource allocation (Bodilly, 1998).

School-level leaders, such as supervisors or coordinators, in a particular subject matter or grade level (e.g., early childhood) serve as essential bridges between administrators and teachers (Cobb, McClain, de Silva, & Dean, 2003). District-level leaders and their decisions also affect implementation (Bodilly, 1998; Klingner et al., 2003; Snipes, Doolittle, & Herlihy, 2002; Spillane, 2000). Communication between principals and all other groups is particularly essential. Principals forgetting the study and their involvement in it and similar communication lapses can be a huge challenge, and it increases with the size of the school district (Foorman, Santi, & Berger, 2007).
Communication  Positive communication, collaboration, and agreement among all groups are essential (Figure 9.1, I; Bryk et al., 2010; Elmore, 1996a; Huberman, 1992; Kaser et al., 1999; Klingner et al., 2003; Sarama et al., 1998). Our own previous research revealed multiple missed opportunities for facilitation of innovations due to the divergent beliefs of social groups, even about ostensibly observable “facts” (Sarama et al., 1998). As one example, the principal of a building answered affirmatively to the question “Is adequate technology available to the teachers?” The teachers said there was not. The principal pointed to the computer laboratory and a schedule giving each teacher access, with “borrowing” time from each other allowed. The teachers countered that 1) many educational technology applications (including the one we were studying) were better situated in the classroom, not a distant computer laboratory; 2) the schedule for the laboratory often did not correspond with their schedule; and 3) borrowing time did not work, because the teachers who did not use the laboratory refused to give up their time and thus tacitly admit that they did not use computers, which the principal wanted them to do.

Teachers and Professional Development  Research suggests that the most critical feature of an educational environment is a knowledgeable and responsive adult and that effective professional development is essential to innovation (Figure 9.1, J, N; Darling-Hammond, 1997; Ferguson, 1991; National Research Council, 2001; Sarama & DiBiase, 2004; Schoen et al., 2003; Sowder, 2007). Scaling up such professional development has special challenges and opportunities in the early childhood setting, as noted previously. Other intervention specifics can affect the strengths of effects, as well. For example, we specify only a weak effect of initial teacher expertise (Figure 9.1, E) because of the low level of mathematics content and pedagogical content knowledge of most prekindergarten teachers, regardless of background (Copley, 2004; Sarama, 2002; Sarama & DiBiase, 2004); this would vary for other goals. Changes in beliefs follow changes in practice (Figure 9.1, N, Q; Showers, Joyce, & Bennett, 1987); moreover, we believe that changes in beliefs help sustain teacher practices (Figure 9.1, Q, S).

Research suggests strategies that help meet those challenges (Klingner et al., 2003; National Research Council, 2001; Sarama, 2002). Use of theory, demonstrations, practice, and feedback, especially from coaches, quadruples the positive effects of information-only training (thus, the model shows strong effects from J and L to N and O in Figure 9.1; see also Foorman et al., 2007; Pelletgrino, 2007; Showers et al., 1987). Effective professional development eschews “one-shot” interventions, begins with a specific strategy or curriculum (Figure 9.1, M), and weaves together content, pedagogy, and knowledge of child development and family relationships (Schoen et al., 2003; Sowder, 2007).

To anticipate, this is one reason that research-based learning trajectories are at the core of our theoretical framework. Learning trajectories are “descriptions of children’s thinking and learning…and a related, conjectured route through a set of instructional tasks” (Clements & Sarama, 2004, p. 83). Thus, learning trajectories have three components: 1) a goal (that is, an aspect of a subject-matter domain children should learn), 2) a developmental progression or learning path along which children move through levels of thinking, and 3) instruction that helps them move along that path. As previously stated, our scale-up model is intended to be general across subject matter and grades. Fortunately, learning trajectories have been or are...
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being developed for many developmental areas (e.g., CCSSO/NGA, 2010; International Reading Association and National Association for the Education of Young Children, 2000; National Research Council, 2007).

**Children and Their Families** Interventions are more effective if they involve parents (Figure 9.1, P), especially by providing activities to do with their children (Bryk et al., 2010; Halpern, 2004; Ramey & Ramey, 1998). As with prekindergarten teachers, parents often have a limited view of the breadth of subject-matter content appropriate for young children (Sarama, 2002). Low-income parents (Figure 9.1, G), compared to middle-income parents, believe that education is the responsibility of the preschool and that children cannot learn aspects of content that research indicates they can learn (Starkey et al., 1999). Communications that change these beliefs are important components of our scale-up model, to which we turn.

**Description of the TRIAD Model for Scale-Up: Research-Based Guidelines**

Our scale-up model is called TRIAD (Technology-enhanced, Research-based, Instruction, Assessment, and professional Development). The model's acronym suggests that successful scale-up must address the triad of essential components of any educational intervention and that the model is based on research and enhanced by the use of technology. However, TRIAD is a general model for scaling up varied educational interventions, based on the Network of Influences framework and research on successful efforts to take such interventions to scale.

Recall our definition of a successful scale-up is instantiation of an intervention in varied settings with diverse populations, addressing the needs of multiple sociopolitical stakeholders, so as to achieve 1) satisfactory fidelity of implementation and, as a result, 2) the intervention's goals for the maximum number of children (>90% in a district) and ultimately, 3) eventual transfer of the intervention to local ownership, sustainability, persistence of effects, and continuing diffusion. In our description of the TRIAD model, we note that some processes are common to successful implementations at any scale, such as work in a single school or classroom (see Guidelines 4 and 5 below); however, although they are helpful in most contexts, the vast majority of the processes are uniquely required for successful scale-up (e.g., we have conducted many research and development projects, such as the efficacy study cited below, that did not substantially involve the other processes or guidelines).

The following summarizes the 10 research-based guidelines in the TRIAD model, connecting it to the original Network of Influences theoretical framework. Implementing these guidelines is the responsibility of an implementation team.

1. **Involve and promote communication among key groups around a shared vision of the innovation** (Hall & Hord, 2001). Emphasize connections between the project's goals, national and state standards, and greater societal need. Promote clarity of these goals and of all participants' responsibilities. School and project staff must share goals and a vision of the intervention (Bryk et al., 2010; Cobb et al., 2003). This institutionalizes the intervention, for example, in the case of ongoing socialization and training of new teachers (Elmore, 1996a; Fullan, 2000; Huberman, 1992; Kaser et al., 1999; Klingner et al., 2003; Sarama et al., 1998).
2. *Promote equity* through equitable recruitment and selection of participants, allocation of resources, and use of curriculum and instructional strategies that have demonstrated success with underrepresented populations (Kaser et al., 1999).

3. *Plan for the long term.* Recognizing that scale-up is not just an increase in number but also of complexity, provide continuous, adaptive support over an extended period of time. Plan an incremental implementation and use dynamic, multilevel, feedback, and self-correction strategies (Bryk et al., 2010; Coburn, 2003; Fullan, 1992; Guskey, 2000). Communicate clearly that change is not an event but a process (Hall & Hord, 2001).

4. *Focus on instructional change that promotes depth of children's thinking,* placing learning trajectories at the core of the teacher–child–curriculum triad to ensure that curriculum, materials, instructional strategies, and assessments are aligned with 1) national and state standards and a vision of high-quality education, 2) each other, and 3) recommended practices, as determined by research, including formative assessment (Ball & Cohen, 1999; Bodilly, 1998; Bryk et al., 2010; Fullan, 2000; Kaser et al., 1999; National Mathematics Advisory Panel, 2008; Raudenbush, 2008; Sowder, 2007). This guideline is important for implementation with fidelity at any scale, although alignment is increasingly important at larger scales.

5. *Provide professional development that is ongoing, intentional, reflective, goal oriented, focused on content knowledge and children’s thinking,* grounded in particular curriculum materials, and situated in the classroom and the school. A focus on content includes accurate and adequate subject-matter knowledge both for teachers and for children. A focus on children’s thinking emphasizes the learning trajectories’ developmental progressions and their pedagogical application in formative assessment. Grounding in particular curriculum materials should include all three aspects of learning trajectories, especially their connections. This also provides a common language for teachers in working with each other and other groups (Bryk et al., 2010).

"Situated in the classroom" does not imply that all training occurs within classrooms. However, off-site intensive training remains focused on and connected to classroom practice and is completed by classroom-based enactment with coaching. In addition, this professional development should encourage sharing, risk taking, and learning from and with peers. Aim at preparing to teach a specific curriculum and develop teachers' knowledge and beliefs that the curriculum is appropriate and its goals are valued and attainable. Situate work in the classroom, formatively evaluating teachers' fidelity of implementation and providing feedback and support from coaches in real time (Bodilly, 1998; Borman et al., 2003; Bryk et al., 2010; Cohen, 1996; Elmore, 1996a; Guskey, 2000; Hall & Hord, 2001; Kaser et al., 1999; Klingner et al., 2003; Pellegrino, 2007; Schoen et al., 2003; Showers et al., 1987; Sowder, 2007; Zaslow, Tout, Halle, Vick, & Lavelle, 2010).

As with the previous guideline, this one is important for implementation with fidelity at any scale. However, the planning, structures, common language, formative evaluation, and school-level context are increasingly important as the implementation moves to larger scales.
6. **Build expectations and camaraderie to support a consensus around adaptation.** Promote buy-in in multiple ways, such as dealing with all participants as partners and distributing resources to support the project. Establish and maintain cohort groups. Facilitate teachers visiting successful implementation sites. Build local leadership by involving principals and encouraging teachers to become teacher leaders (Berends et al., 2001; Borman et al., 2003; Elmore, 1996a; Fullan, 2000; Glennan, Bodilly, Galegher, & Kerr, 2004; Hall & Hord, 2001).

7. **Ensure school leaders are a central force supporting the innovation and provide teachers with continuous feedback that children are learning what they are taught and that this learning is valued.** Leaders, especially principals, must show that the innovation is a high priority, through statements, resources, and continued commitment to permanency of the effort. An “innovation champion” leads the effort within each organization (Bodilly, 1998; Bryk et al., 2010; Glennan et al., 2004; Hall & Hord, 2001; Rogers, 2003, p. 434; Sarama et al., 1998).

8. **Give teachers and schools latitude for adaptation, but maintain integrity.** Emphasize the similarities of the curriculum with sound practice and what teachers already are doing. Help teachers distinguish productive adaptations from lethal mutation (Brown & Campione, 1996). Also, do not allow dilution due to uncoordinated innovations (Fullan, 2000; Huberman, 1992; Sarama et al., 1998; Snipes et al., 2002).

9. **Provide incentives for all participants, including intrinsic and extrinsic motivators linked to project work, such as external expectations—from standards to validation from administrators.** Show how the innovation is advantageous to and compatible with teachers’ experiences and needs (Berends et al., 2001; Borman et al., 2003; Cohen, 1996; Darling-Hammond, 1996; Elmore, 1996b; Rogers, 2003).

10. **Maintain frequent and repeated communication, assessment (“checking up”), and follow-through efforts at all levels within each school district, emphasizing the purpose, expectations, and visions of the project, and involve key groups in continual improvement through cycles of data collection and problem solving** (Fullan, 1992; Hall & Hord, 2001; Huberman, 1992; Kaser et al., 1999; Snipes et al., 2002). Throughout, connections with parents and community groups are especially important to meet immediate and long-range (sustainability) goals.

### Empirical Evaluation

A series of studies has been conducted to evaluate instantiations of the TRIAD model and its components (Clements & Sarama, 2008a, 2008b; Clements, Sarama, Spitler, Lange, et al., 2011; Clements, Sarama, Wolfe, & Spitler, in press; Sarama & Clements, 2009; Sarama, Clements, Starkey, Klein, & Wakeley, 2008). The main studies are summarized below.

Two experiences with the **Building Blocks** curriculum (Clements & Sarama, 2007/2013) convinced us that we needed a model of scale-up. Early efficacy studies without the supports described previously resulted in large effect sizes (1–2
standard deviations), but this was in a small number of classrooms (Clements & Sarama, 2007). Invited to another state to present the curriculum, follow-up visits revealed spotty implementation, at best, despite our enthusiastic presentations.

After developing the TRIAD model, we conducted an initial evaluation in 25 prekindergarten classrooms serving children at risk for later school failure (about half Head Start and half public preschool programs). We assigned volunteer teachers to either a TRIAD or a control group (Sarama et al., 2008). We attempted to implement most components of the TRIAD model (some, such as planning for the long term, were not possible in this limited scale-up). For example, we began by meeting with administrators and teachers to encourage them to have a shared understanding of the goals of the intervention. We provided incentives in the form of rationales for the intervention and the provision of curriculum materials and especially professional development. Adequate fidelity (e.g., an average of agree on a four-point Likert scale from strongly disagree to strongly agree for all fidelity measures) led to strong gains in mathematics achievement (effect size = .62).

Our largest implementation and evaluation to date involved 1,375 preschoolers in 106 classrooms serving low-resource communities in two states. This implementation was also the most valid and therefore generalizable because the administration of both school systems agreed to the implementation across their districts. Therefore, we could both randomly select and randomly assign schools. Further, teachers were not volunteers—a common limitation in many such studies. We attempted a complete implementation of the TRIAD-based intervention in these two school districts. This led to similar results, including adequate fidelity and outcomes for children (effect size = .72). Further, the TRIAD group outperformed children in the control group on a measure of oral language, suggesting general educational benefits (Sarama, Lange, Clements, & Wolfe, 2012).

Finally, we have investigated sustainability. Preliminary analyses are positive; for example, fidelity at multiple levels (intervention and implementation) has increased in the 4 years since the end of support from the funded research project. In the following section, we concretize the TRIAD model by describing the guidelines that were instantiated in this last study.

### Implementation of the TRIAD Scale-Up Model: An Illustration

Our definition of scale-up and our TRIAD model suggest an incremental implementation of the intervention, including introduction, adoption, initial implementation, improved implementation, and structural accommodations, institutionalization, and diffusion. In this study, the introduction was through negotiations with administrators, although some members of each school district had cooperated on some aspect of the formation and early piloting of the materials.

1. **Involve and promote communication among key groups around a shared vision of the innovation.** In our work, the team that "makes it happen" is organized and led by the researchers. We expect different teams to instantiate the model within districts or other organizations. The implementation team began by meeting with administrators and teachers to encourage them to have a shared understanding of the goals of the intervention. Presentations, brochures, and a video of previous implementations provided both the rationale for the
intervention and the particulars of it to broad audiences of administrators, coordinators, supervisors, teachers, and parents. We highlighted alignment to national, state, and district goals and showed how the intervention met those goals with specific examples.

2. **Promote equity.** We showed how past evaluations of the intervention helped close achievement gaps. We explained the phased adoption (each teacher receives all the benefits, with the schedule determined fairly with public random selection). We discussed allocation of resources with principals and upper administration.

3. **Plan for the long term.** We worked with administrators to plan the incremental implementation (i.e., phased adoption) and to garner support for our use of formative assessment for the intervention (e.g., more coaching is provided immediately for those teachers who request it or show any signs of struggling). We obtained agreement to allow “release time” for not only teachers but also teacher assistants, coordinators, and supervisors to attend the professional development sessions and classrooms to generate long-term commitment to sustaining the intervention past the end of the funded support.

4. **Focus on instructional change that promotes depth of children’s thinking, placing learning trajectories at the core.** Meetings of every type were illustrated with examples of children’s thinking and learning and of the teacher–child–curriculum interactions that promote development along learning trajectories. The learning trajectories became useful “boundary objects” that helped facilitate coordination and communication among those in varied educational roles. Similarly, they served to align standards, curriculum, and assessment.

5. **Provide professional development that is ongoing, intentional, reflective, goal oriented, focused on content knowledge and children’s thinking, grounded in particular curriculum materials, and situated in the classroom and the school.** The first year was a “gentle introduction” to the curriculum with no pressure from assessments, because our previous experience and others’ research suggested that teachers often need at least a year of experience before completely and effectively implementing a curriculum (Berends et al., 2001; Clements & Sarama, 2009; Cobb et al., 2003). Thus, teachers participated in 8 full days of professional development during the school day, beginning with 2 consecutive days and about 1 day per month for the rest of the year.

Introductory discussions emphasized the “developmental appropriateness” of the intervention’s mathematics education and its importance to the teachers and children, especially in promoting equity. This work focused on the learning trajectories for each mathematical topic, usually as woven into the Building Blocks curriculum.

Training addressed each of the three components of the learning trajectories. To understand the goals, teachers learned core mathematics concepts and procedures for each topic. For example, they studied the system of verbal counting based on cycling through 10 digits and the concept of place value (based on content similar to that presented in National Research Council [2009]). To understand the developmental progressions of levels of thinking,
teachers studied multiple video segments illustrating each level and discussed the mental “actions on objects” that constitute the defining cognitive components of each level. To understand the instructional tasks, teachers studied the tasks, and they viewed, analyzed, and discussed video of the enactments of these tasks in classrooms.

A central tool to study and connect all three components was the web-based software application Building Blocks Learning Trajectories (BBLT), which provides scalable access to the learning trajectories via descriptions, videos, and commentaries. Two sequential aspects of the learning trajectories—the developmental progressions of children's thinking and connected instruction—are linked to the others. Teachers used the “Test Yourself” feature of the BBLT to evaluate their abilities to diagnose children’s level of counting (by identifying the level evinced by children in randomly selected videos). They also used the BBLT's links to view research-based instructional strategies to promote children's progress to the next level.

Teachers worked in small groups to plan how activities from their curriculum might promote, or be modified to promote, learning for the relevant levels. The coaches and project staff joined the teachers in the professional development activities, as well as several days of training on coaching, most of which focused on the unique aspects of mentoring/coaching early mathematics education. Coaches worked with teachers during the year to avoid dilution of the intervention, to promote productive adaptations, and especially to provide teachers with continual feedback and support.

In Year 2, teachers and mentors participated in an additional 5 days of professional development spread throughout the year. They continued to study the learning trajectories, including discussions of how they conducted various curricular activities the previous year. As part of this work, teachers brought case studies of particular situations that occurred in their classrooms to the group to facilitate these discussions; thus, this work included elements of lesson study.

6. **Build expectations and camaraderie to support a consensus around adaptation.** Beyond what has already been described, the curriculum-based assessments also built local leadership by involving each district’s early childhood and mathematics specialists in all our planning meetings and professional development sessions to plan for sustainability. We encouraged them to rely on teachers in our sessions as teacher leaders to support wider implementation after the conclusion of the data collection.

7. **Ensure school leaders are a central force supporting the innovation and provide teachers with continuous feedback that children are learning what they are taught and that this learning is valued.** Similarly, we involved principals in as many meetings and classroom visits as their schedule allowed (only a handful ever attended professional development sessions, although they were invited). We created a “walk-through” version of the classroom fidelity instrument for supervisors and principals. This form helped make the implementation more concrete and visible and helped the administrators assist teachers in developing their skills more effectively. The form also served as a way to communicate our goals to both teachers and administrators.
8. **Give teachers and schools latitude for adaptation, but maintain integrity.** For example, help teachers learn to change surface features (e.g., changing the pictures on a game board to fit a class “theme”) without altering the core components of the instruction (Winter & Szulanski, 2001). These are productive adaptations (Brown & Campione, 1996). In contrast, a lethal mutation might simplify the rules of a board game to avoid the need for children to interact with the mathematics.

9. **Provide incentives for all participants, including intrinsic and extrinsic motivators linked to project work.** We provided incentives in the form of rationales for the intervention and the provision of curriculum materials and especially professional development.

10. **Maintain frequent and repeated communication, assessment (“checking up”), and follow-through efforts.** We met with supervisors (both of early childhood education and of mathematics education) and principals on a regular basis. Our staff monitored signs for any source—teachers, coordinators, administrators, and parents—to address any problems or blockages before they became serious.

In summary, evidence supports the effectiveness of this instantiation of the TRIAD model. We are presently working on complex statistical analyses that identify which components of the model were most important. The next section addresses such questions qualitatively. (Institutionalization and diffusion are occurring at the time of this writing; we discuss this briefly and will address this issue in more detail in future reports.)

**Lessons Learned**

TRIAD was implemented well and had positive effects. What else have we learned?

- **Efforts will be more effective if they are based on scientifically validated early childhood interventions.** Early childhood educators frequently champion the individual teacher's interpretation of and even creation of the educational program. In contrast, this body of work suggests that implementation of systematic, scientifically based practice is more effective than private, idiosyncratic practice (Raudenbush, 2009). This is not to say that teachers should deliver “scripted” curriculum; indeed, such an approach contradicts TRIAD's use of hypothetical learning trajectories in the service of formative assessment and its insistence on adaptation to local conditions (Guideline 8). Rather, focusing on the shared scientific base is a more effective and efficient way to improve education for children. Furthermore, such scientifically grounded shared practice is, somewhat paradoxically, more likely to generate creative contributions. Teachers will constitute modifications of effective practice that are already shared, and thus understood and more easily adopted, and that in turn will be accessible to discussion and further scientific investigation. We found it crucial to help teachers differentiate between productive adaptations and lethal mutations (Brown & Campione, 1996) to the intervention. In a similar vein, the introduction of uncoordinated interventions had to be continually monitored for the effects they may have on the intervention. This leads to the next lesson.
• **It is critical that all teachers receive professional development.** Our data suggest that certain factors are sine qua non for an effective scale-up effort. Our evaluations (including mediators of effects, not discussed here due to space constraints) indicate that effectiveness depends on the development of teachers’ skills and knowledge (i.e., Guideline 5). A total of 50 to 70 hours of professional development— we provide about 75 hours—is consistent with previous research documenting what is necessary to achieve measurable effectiveness (Yoon, Duncan, Lee, Scarloss, & Shapley, 2007). Situating the materials not just in the classroom but also at each school is important for related but additional reasons. Because it establishes a cultural practice and provides peer support, school-based implementation supports both fidelity and sustainability of a new curriculum (Zaslow et al., 2010) and reaches more than 90% of students in the school (not just one classroom, hoping for “spillover”). Several findings indicate that learning trajectories played a critical role in both teachers’ and children’s learning (Guideline 4). Finally, respect of teachers by project staff and the resultant acceptance of in-class support from coaches and technology support staff appeared to be as or more important than whole-group professional development sessions. Note that this was especially striking in another later project in which we used coaches employed by the school district. They were not able to schedule meetings regularly and our initial impressions are that they were not as effective. If valid, this has serious ramifications for scaling up coaching-intensive models.

• **Consistent communication with and among all key groups promotes implementation and sustainability.** Project activities would not have been achieved without consistent communication and continued collaboration (Guidelines 1, 7, and 10). We found it necessary to repeatedly provide higher level administrators with updates and reminders of the projects’ goals and activities. Similarly, every change in administration had to be monitored and new people introduced to the project and its successes quickly. The early introduction of the project was facilitated by prior awareness of the researchers’ work and a strong commitment to achieving the project goals. A challenge is to institutionalize such continuous commitments within each district. Presentations of the evaluations and corresponding discussions of how to maintain the implementation infrastructure within the organization appeared to have positive effects on sustainability. Also significant was the implementation team’s consistent efforts to involve midlevel staff, such as supervisors and coordinators, in professional development sessions, classroom visits, and separate meetings. Such involvement created essential advocates for the intervention within the organizations.

• **Fidelity tools are important for research, but also for implementation fidelity.** We quickly saw the need for additional formats for the classroom observation tools. For example, we created an “iFidelity” form for use by coaches and teachers. It simply changed the grammatical structure to say, for example, “I began by engaging and focusing children’s mathematical thinking” (Clements & Sarama, 2000/2012). More importantly, everyone understood that no one but the teacher and coach would see the completed forms. They were for self-directed professional development. Tools such as these and the similar “walk-through” version for supervisors and principals should aid institutionalization of future
monitoring of fidelity of implementation at the local site and help ensure that practices are sustained.

- **Maintaining the model for new teachers is challenging.** Having districts maintain the model for new teachers has been a serious challenge. Even districts that collaborated on generating the research that showed the effectiveness of the model and the necessity of it asked us to provide a two-hour workshop to replace the 12 days of professional development.

  We are tracking diffusion within districts, but especially to surrounding districts (Dearing et al., 2006). The availability of teacher trainers and independent coaches was especially crucial at one site, as they were asked by administrators of nearby school districts who had heard about the implementation to build new implementation teams within their districts. Having in-house leaders (e.g., early childhood and mathematics supervisors or coordinators) organize and lead such teams not only is logistically important but also promotes positive spread and shift in ownership (Glennan et al., 2004).

- **Leaders of the implementation team must understand the components and collaborate with others.** Each rigorous evaluation project so far has been led by the developers, and this is a challenge for future research. Fortunately, the just-mentioned diffusion to surrounding districts provides at least anecdotal evidence that this is possible. That is, we know that it appears necessary to have leaders from outside or inside the district who have knowledge of, and a serious commitment to, the implementation. However, in the case of the diffusion we have observed, it was not necessary for these leaders to be experts in the scale-up model, curriculum, professional development, and other components. As long as they understood the components and collaborated with others who were experts (such as those who have served as coaches in a previous implementation, in our instance), the implementation was complete and successful. Again, these hypotheses based on informal observations need to be evaluated.

**Final Words**

The goal of the TRIAD project was to create a theoretically and empirically grounded model of scale-up and to increase knowledge of scaling-up by conducting research that investigates the effectiveness of an instantiation of that model. Evaluations indicate that the TRIAD model shows promise in scaling up at least one educational intervention across a large number of diverse populations and contexts in the early childhood system, avoiding the dilution and pollution that often frustrates interventionists. This supports not only the TRIAD model but also the more general hypothesis that intentional, theoretically and empirically based models can support initial interventions, scale-up, and sustainability.

Still, many challenges remain. First, our research design could not identify which components of the TRIAD model and its instantiation are critical components. Such research would be theoretically and practically useful.

Second, our research supports a major guideline of the TRIAD model, the use of learning trajectories, contributing to the growing research corpus that supports the educational usefulness of learning trajectories, including evaluations of curricula built on them (Clements & Sarama, 2007, 2008a; Sarama et al., 2008), elementary
curricula based on related trajectories such as Math Expressions (Agodini & Harris, 2010), studies of successful teaching (Wood & Frid, 2005), and professional development projects (Bright, Bowman, & Vacc, 1997; Clarke et al., 2002; Wright, Martland, Stafford, & Stanger, 2002). This supports the use of such structures in standards, such as the recently released Common Core State Standards (CCSSO/NGA, 2010). Again, however, the specific contribution of the learning trajectories per se needs to be disentangled and identified.

Third, our intent has always been that the TRIAD model should generalize to other subject-matter domains and other age and grade levels. TRIAD’s 10 research-based guidelines are consistent with, but more detailed than, generalizations from the empirical corpus (Pellegrino, 2007). However, the model has not been implemented outside of the early childhood age range or in other subject-matter domains. Evaluations of such varied implementations are needed. For example, for certain subject-matter areas such as science and aspects of literacy, learning trajectories appear to be viable and useful. It may be that for other areas of language, or for literature or the social sciences, some but not all of the TRIAD guidelines constitute “core components.” Addressing these challenges will make further contributions to the education sciences.

References


