Evaluation of Professional Development in the Use of Arts-Integrated Activities with Mathematics Content: Findings About Program Implementation

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Abstract

In 2010, the Wolf Trap Foundation for the Performing Arts, Institute for Early Learning Through the Arts, was awarded an Arts in Education Model Development and Dissemination (AEMDD) grant to develop, implement, and disseminate a research-based program of professional development (PD) that equips prekindergarten and kindergarten teachers to infuse mathematics instruction with arts instruction in their classrooms. The PD includes summer institutes and classroom-based residencies in which music, dance, and drama performing artists work with teachers in teams. This instructional approach is often called *arts integration*. American Institutes for Research (AIR) conducted an evaluation of the four-year grant from 2010-2014, examining the implementation of the PD and assessing its impact on teacher practices and student mathematics knowledge. This article reports on the experiences of the elementary school teachers and Wolf Trap teaching artists in the first cohort of participating schools during 2011–12 and 2012–13, drawing on data from a variety of sources (PD observations, residency artifacts, artist interviews, and teacher surveys). We find that the Wolf Trap PD program demonstrates features of effective PD. It is classroom-based, intensive, and focused on what teachers and students need to know to teach and learn mathematics. It is aligned with district standards and offers many opportunities to teachers for active learning. The Wolf Trap PD program delivered preparation to teachers to infuse performing arts-based strategies into their mathematics instruction, starting in the PD institutes and then continuing in the residencies and did so with fidelity to the planned model. Wolf Trap used several approaches to optimize fidelity: a planning year and practice sessions with teaching artists, consistent use of local content experts, and materials structured to reflect the concepts and approaches used in both institutes and residencies. The article concludes with suggestions for practitioners and questions for further research.

Introduction[i]

Study Context

In 2010, the Wolf Trap Foundation for the Performing Arts, Institute for Early Learning Through the Arts (Wolf Trap),[ii] was awarded an Arts in Education Model Development and Dissemination (AEMDD) grant (http://www2.ed.gov/programs/artsedmodel/index.html) to develop, implement, and disseminate a research-based program of professional development (PD) that equips teachers to infuse mathematics instruction with performing arts instruction in their prekindergarten and kindergarten classrooms. The PD program developed by the Wolf Trap's project team[iii] includes annual summer institutes as well as in-classroom coaching during the school year. In the summer institutes, Wolf Trap teaching artists in the disciplines of dance, music, and drama work with teachers in teams to develop standards-based performing arts and mathematics experiences. During the school year, teachers and teaching artists work together in partnership, planning, and implementing lessons in the classroom—a research-based strategy often called the *artist residency model* (Burnaford, 2007).

American Institutes for Research (AIR) conducted a four-year evaluation of the Wolf Trap AEMDD grant project. The purpose of the evaluation is to examine the implementation of the Wolf Trap PD program and assess its impacts on teacher practice (use of performing arts strategies in particular) and students' mathematics knowledge. This article presents findings related to the implementation of the program.

Arts Integration

The Wolf Trap PD program focuses on arts integration. *Arts integration* has been defined as instruction that integrates content and skills from the arts with content and skills from other core subjects, with the intent of increasing learning in both areas (Ruppert & Habel, 2011). For instance, a teacher might integrate mathematics and dance content by teaching patterns with dance movements, so that learning in one subject enhances learning in the other. Arts integration is often facilitated by teaching artists, who are an essential component of arts-integration programs (Freeman, Seashore, & Werner, 2003). Rabkin and Redmond (2004, p. 137) have suggested salient features of arts-integrated instruction are:

1. Teacher-artist teams link an art form and an academic discipline.
2. Student groups' work in the art form is central to the experience and to continuous assessment.
3. Content includes material related in meaningful and direct ways to students' experiences.
4. Units have a balanced focus on academic content, academic skills, arts skills, and arts content.
5. Units include basic skills and higher-order skills.
6. Units usually culminate with an artistic product that demonstrates student learning of content and skills and contributes to the public culture of the school community.

Rabkin and Redmond (2004) also note that institutional, school, and community level elements (e.g., districts' arts standards, current PD for teachers, and schools' prior experiences with arts) are important to the success and sustainability of arts-integration initiatives.

Research indicates that arts integration has great potential for student learning in multiple disciplines (Burnaford, 2007; Goff & Ludwig, 2013). For example, Ingram and Reidel (2003) reported finding a significant positive link between in-school arts-integrated programming (as part of the Arts for Academic Achievement program) and standardized test scores. Similarly, Catterall and Waldorf (1999) reported that children in Chicago arts-integrated elementary schools perform better on tests than those in control schools. In the field of early childhood education, Erdoğan and Baran (2009) reported that drama-infused mathematics instruction for Turkish six year-olds was associated with their mathematics achievement test scores. Researchers have also found nonacademic effects in studies of arts integration; for example, teachers and classroom observers have reported improvements in students' creative and critical thinking abilities after arts-integrated programming (Curva and Associates, 2005; Randi Korn & Associates, 2005; Randi Korn & Associates, 2010).

There is also research evidence supporting the Wolf Trap approach to arts integration. In a randomized controlled trial of a Wolf Trap sponsored literacy-focused initiative, for example, students in treatment schools (schools where teachers participated in the summer PD and worked with teaching artists in residencies) were found to outperform their counterparts in control schools on the Child Observation Record scales of initiative, social relations, creative representation, language and literacy, logic and mathematics, and movement and music (Klayman, 2006).

PD (Institutes and Coaching)

The study we are reporting on is in the tradition of studies investigating the impact of PD on teacher practices and student outcomes (Garet et al., 2008; 2011). The logic model that guides our study suggests that effective PD will lead to improved teacher knowledge and practice, which will in turn contribute to improved student achievement outcomes. The PD features examined in this study are the six features of high-quality PD identified in prior research: form, focus on content, active learning, coherence, duration and collective participation (Garet, Porter, Desimone, Birman, & Yoon, 2001).

Because artist residencies are integral to the Wolf Trap PD, the study also focuses on classroom coaching as an important form of PD—one that has been shown to lead to teacher acquisition of knowledge and skills (Joyce & Showers, 1995). The literature defines four forms of coaching: technical, problem solving, reflective practice, and building a community of learners (AIR, 2005). The work of the teaching artist can be viewed as technical coaching (i.e., instruction in a particular technique). Teaching artists are focused on teaching behaviors that are applied to a particular subject but that can be applicable more broadly and are closely aligned with the curriculum and pedagogy (Kennedy, 1998). In the Wolf Trap PD approach, teaching artists are also conducting a form of coaching intended to build a community of learners. An instructional coach typically supports teachers in the use of instructional strategies in one content area. The teaching artist is required to hold two content areas in balance while understanding the learning needs of early childhood students. This is a unique type of coaching that deserves more attention in terms of its impact (Rabkin, Reynolds, Hedberg, & Shelby, 2011).

Over the past decade, additional studies and reviews of studies have offered new insights into how some of the features of high-quality PD identified in prior research are related to changes in teacher practices and student outcomes. For example, Yoon, Duncan, Lee, Scarloss, and Shapley (2007) reviewed nine rigorous studies of PD in which the PD was delivered to teachers directly. They found that studies with PD programs of more than 14 hours showed a positive and significant effect on student achievement, and that teachers who receive substantial PD, an average of 49 hours in the nine studies reviewed, markedly boosted student achievement.

However, some researchers are challenging the study of the relationships between those PD features and teacher practice outcomes. In a recent review of knowledge emerging from studies of PD, Wilson (2013) notes that rigorous research has "yet to produce conclusive support for those characteristics" and that "problems include a lack of sound measures and [lack of] a strong theoretical understanding of the mechanisms of teacher learning." (p. 311) Some researchers are focusing on defining high-level teacher practices and classroom features associated with student achievement (http://www.teachingworks.org/). In the coming years, research on PD may shift from the general features that we study in this evaluation to PD for specific practices.

Research Questions

The purpose of this article is to present findings related to the implementation of the Wolf Trap PD program obtained from a larger evaluation of the program. The research questions (RQs) addressed in this article are as follows:

1. To what extent does the Wolf Trap PD represent the six features of high-quality PD identified in prior research?
2. Is the Wolf Trap PD implemented with fidelity? That is, does the Wolf Trap PD program (summer PD institutes and residencies) deliver PD that prepares classroom teachers to infuse performing arts-based strategies into their mathematics instruction, as intended?

The above questions, as well as questions about the program's impact on teacher and student outcomes, are addressed with a randomized controlled trial with school-level random assignment. Details of the study design are described in the Methods section.

Methods

In this section, we explain the study sample, measures and data collection for the larger study, and the analytic approach used to address the two RQs related to program implementation.

Sample

For this study, Wolf Trap recruited 22 elementary schools in total over two years from one large district—six schools (three treatment and three control) in 2011 (Group 1 schools) and 16 schools (eight treatment and eight control) in 2012 (Group 2 schools). To recruit schools for the study, Wolf Trap and its partner school district worked with the superintendent's office, the research office, and the Title I office of the district to disseminate information about the study in the superintendent's newsletter, at Title I principal meetings, and in letters to principals. The information in the communications explained the study conditions and requested that teachers from prekindergarten and

kindergarten classrooms in each school consider participation. Schools that were willing to participate in the study were randomly assigned to receive the Wolf Trap PD program (i.e., treatment schools) or to the business-as-usual condition (i.e., control schools).

All six Group 1 schools remained in the study over the two years of implementation. Four of the 16 Group 2 schools left the study before study activities began. The treatment schools remaining had an average enrollment of 1,158 students, with an average of 47.9 percent of students eligible for free or reduced-price lunch. The control schools remaining had an average enrollment of 1,055 students, with an average of 41.7 percent of students eligible for free or reduced-price lunch.

In each school, prekindergarten (including Head Start) and kindergarten teachers were invited to participate in the study. The number of prekindergarten and kindergarten classrooms in each school varied and shifted in each group over the two implementation years. Across the two groups of schools, we recruited a total of 80 teachers, 64 of whom completed a baseline survey that gathered information about their backgrounds and prior experience. Among treatment teachers, 46 percent taught kindergarten and 43 percent taught prekindergarten. Among control teachers, 60 percent taught kindergarten and 32 percent taught prekindergarten. The other participating teachers (11 percent of treatment teachers and 8 percent of control teachers) were special education teachers who worked with multiple classrooms and teachers who taught combined kindergarten and first-grade classes. From the classroom of each participating lead teacher, we randomly selected eight students for the assessment of mathematics knowledge, the key student outcome measure.

Data Collection

AIR's evaluation of the Wolf Trap project draws on multiple data sources from teachers, teaching artists, and students. Table 1 shows the data collection activities, participants, and schedule for the overall evaluation. A description of the data collection instruments follows.

Table 1. *Data Collection and Participants*

Data Collection Activity	Participants	Schedule of Data Collection
Teacher baseline survey[a]	All treatment and control teachers	Group 1: summer 2011 (treatment), fall 2011 (control) Group 2: summer 2012 (treatment), fall 2012 (control)
Observations of classrooms[b]	All treatment and control teachers	Before and after residencies (Some teachers in Group 2 were still participating in residencies in 2013–14.)
Online survey of teachers regarding Wolf Trap services	All treatment teachers	Annually conducted by Wolf Trap
Observations of the PD institutes[c]	Treatment teachers and teaching artists	Each summer when the institutes were delivered and midyear meetings for teachers and teaching artists

Data Collection Activity	Participants	Schedule of Data Collection
Teaching artist residency planning forms[d] and lesson plan forms[e]	Teaching artists and treatment teachers in residency activities	Submitted at the end of each group of residency visits by artists for assigned teachers (selected sample used for analysis)
Interviews with teaching artists[f]	All teaching artists	June 2013
Early Math Diagnostic Assessment (EMDA), an instrument developed by Pearson and distributed by PsychCorp	Sample of eight students from the class taught by each treatment and control teacher	Baseline test in the fall of the first implementation year and follow-up test in the spring of each implementation year. Parental consent was sought for participation in this assessment.

[a] Survey available at: http://www.wolftrap.org/~/media/files/pdf/education/wolf_trap_teacher_survey.ashx.

[b] Classroom observation form available at: http://www.wolftrap.org/~/media/files/pdf/education/classroom_observation_form.ashx.

[c] PD Institute observation form available at: http://www.wolftrap.org/~/media/files/pdf/education/blank_2012_pd_obsvform.ashx.

[d] Example residency planning form available at: http://www.wolftrap.org/~/media/files/pdf/education/Planning_Form.ashx. Residency planning form analysis rubric available at: http://www.wolftrap.org/~/media/files/pdf/education/blank_residency_planning_form_analysis_spreadsheet.ashx.

[e] Example lesson plan available at: http://www.wolftrap.org/~/media/files/pdf/education/Early_STEM_Arts_Lesson_Plan.ashx. Lesson plan analysis spreadsheet available at: http://www.wolftrap.org/~/media/files/pdf/education/blank_lesson_plan_analysis_spreadsheet.ashx.

[f] Interview protocol available at: http://www.wolftrap.org/~/media/files/pdf/education/Interview_protocol.ashx.

Information about the data collection activities was first disseminated to principals and teachers through introductory letters about the project. At key points in the project schedule, information was prepared and shared with teachers and parents about the type, schedule, and purpose of data collection: at entry into the study, at survey administration, prior to classroom observations, and prior to sampling students for participation in the EMDA assessment.

Surveys. AIR administered the Professional Development and Instructional Practice (PDIP) survey to both treatment and control teachers. The PDIP survey contains items about the teacher's assigned grade level, number of students, teaching experience, PD experience, and instructional practices in teaching mathematics.[iv] The items have been analyzed and shown to be reliable and valid. Wolf Trap also conducted an online service-focused survey with treatment teachers.

Observation forms. Two observation forms were developed for this study. The observation form for the summer institutes was based on PD observation forms used in two national studies of PD impact on reading and mathematics (Garet et al., 2008, 2011). This form was grounded in the agenda for the summer institutes and the elements of the PD that were anticipated (e.g., a focus on mathematics content, inclusion of arts, and linking of arts and mathematics). The classroom observation form delineated the same content foci, and gathered narrative description of the classroom and the

instruction observed, as well as questions about the extent to which the lesson exhibits various features of arts integration and elements of the Wolf Trap model of PD.

Documentation from artists. At the end of two years of a teaching artist residency, AIR received documentation from Wolf Trap submitted by the teaching artists that included the residency and the lesson planning forms. The residency form was the overall plan for coaching. It identified the curriculum standards for the residency and other skills (social-emotional, language, cognitive, and motor skills), goals (mathematics standard, curriculum focus, arts-strategy skill), and schedule. The plan was accompanied by a debriefing form with stimulus questions to process the outcomes with the teacher. The individual lesson plans are intentionally structured for coherence with the residency form and cover arts and mathematics concepts, PD skill focus, identification of vocabulary, objectives, teacher questions, procedure, assessment strategies, modifications, extension experiences, and a description of the lesson procedure.

Interviews. AIR interviewed the nine teaching artists working with the first group of treatment teachers in 2011–13. These phone interviews asked the artists about their overall experience in the role, their preparation for the Wolf Trap project, and their views about the experience of the teachers with whom they worked.

Student assessment. The EMDA was selected for the assessment of students' mathematics knowledge with the approval of the partner district and the AEMDD project officer. The EMDA is appropriate for diagnostic and achievement testing for students in prekindergarten through Grade 3. It consists of two tests: math reasoning and numerical operations. The test is administered individually, and the resulting raw scores can be translated into levels of proficiency (emerging, basic, and proficient).

Analysis Approach

To investigate the alignment of the Wolf Trap PD to features of effective PD identified in prior research (RQ1), and to determine the extent to which the PD was implemented with fidelity (RQ2), AIR analyzed data from observations of the summer PD institutes, documentations maintained by the teaching artists, and interviews with teaching artists regarding their experience in the artist residencies.

To analyze the qualitative documentation gathered in the study (e.g., PD agendas and participant binders, observation spreadsheets and qualitative notes, and residency plans and lessons), we first developed a model of the components of the Wolf Trap PD that had emerged from observing the 2011 summer institutes. We defined each construct (i.e., arts strategies) and reviewed all data sources to determine whether they were appropriate for each implementation question.[v] AIR then developed rubrics for the six features of high-quality PD and the components of the Wolf Trap PD approach and identified a standard of evidence for each feature based on the literature reviewed. Two AIR analysts reviewed various project documents and identified examples that matched the evidence standard. The documents reviewed included observation forms and narrative descriptions of all days of PD institutes, a sample of nine overall residency plans, and a sample of 20 lesson plans collected from the teaching artists reflecting their work with the teachers over the two implementation years.

Findings

Features of PD

In this section, we report on the extent to which the Wolf Trap PD institutes and residencies exhibited the six features of effective PD—form, focus on content, active learning, coherence, duration and collective participation—that have been shown to influence teacher practice and student learning (Garet et al., 2001) (RQ1).

Form. Wolf Trap and the teaching artists delivered PD that included training for teaching artists, a summer institute, and coaching, all of which were characterized by active and reform orientations to PD, as compared with traditional PD sessions (Garet et al., 2001).

Focus on content. Teachers were expected to come to Wolf Trap's PD program with expertise in early childhood mathematics instruction and early childhood pedagogy from their education and classroom experience. The Wolf Trap PD program primarily covered how to infuse arts-integrated strategies into mathematics instruction, and, to a lesser extent, what students were expected to know in mathematics, as well as early childhood pedagogy strategies teachers could use to instruct students.

Active learning. The PD institutes gave teachers the opportunity to engage in five of the six elements of active learning associated with effective PD: observe demonstrations; practice what they learned and receive feedback; lead group discussions; conduct a demonstration (of a lesson, unit, or skills); and develop and practice using student materials (Garet et al., 2001). The residencies gave teachers the opportunity to engage in all six elements of active learning—the five mentioned earlier, as well as "reviewing student work or scoring assessments." In the residencies, artists reported working with teachers to identify where students were having difficulties in their classroom and how to use arts-integrated strategies to facilitate progress. In contrast, the institutes included minimal discussion of student performance generally, except in small-group discussions when teachers described what and how they were currently teaching.

Coherence. The Wolf Trap PD delivered to teachers aimed to be consistent with district mathematics standards for early childhood and included attention to these standards in the PD binders, in presentations during the institutes, and in planning and implementing the residencies.

Table 2 summarizes the content components of the Wolf Trap PD institutes. Table 2 also indicates where opportunities of active learning and coherence were present.

Table 2. *Summary of Components, Content, and Key PD Features of the Wolf Trap Summer Institutes*

Institute Components	Description of Content and Identification of Key PD Features
Residency and overall project information	• Throughout the institute, members of the Wolf Trap project gave brief introductions and procedural presentations about the residencies, administrative paperwork, the evaluation, and the availability of resources for teachers.
Mathematics content	• Each year, on Day 1 of the institute, a presenter from the local Office for Children gave an overview of current thinking in the field about how young children learn mathematics content and what students in prekindergarten and kindergarten are expected to know and be able to do regarding mathematics. • Additional resources came from mathematics experts via videos and institute participation. • Coherence with district standards was evident as the presenters specified the content standards; binders contained district documents with standards and pacing information.
Arts discipline content	• Each year, on Day 1 of the institute, teaching artists from the fields of dance, music, and drama each gave 30 to 35-minute presentations introducing teachers to the art forms and their fundamental elements. There were other selected times during the institutes when artists presented information about their performing arts disciplines. • In the follow-up institute in summer 2012, artists and teachers devoted additional time to expand their understanding of the performing arts disciplines. • Active learning was evident as teachers were engaged in demonstrations of performing arts. Teachers used props and materials in the arts, practiced what they were learning, and often experienced the activities in the role of student.
Using arts-integrated strategies to teach mathematics (may include both arts and early pedagogy strategies)	• The majority of the instruction-focused time at the institute focused on arts integration, or linking performing arts and mathematics so that learning in one area enhances the other, and all 30-plus lesson plans in the PD institute binders focused on this approach. • These segments involved coherence (linkage with district curriculum standards) and were notable for the expectation that teachers would be active participants.
Small-group discussions among teachers regarding current practice	• In Days 2 and 3 of the summer PD institute, after each artist presented initial examples of arts-integrated strategies related to specific mathematics topics, teachers assembled in small groups with artists to discuss their current classroom practices regarding that topic (e.g., number sense) and their perceptions of how the arts-integrated strategies would work for their students. • Teachers sometimes led discussions in these meetings and discussed the importance of student learning needs and classroom features, evidencing active learning.

Institute Components	Description of Content and Identification of Key PD Features
	• Each of these small-group sessions began with a discussion of the current instructional attention to content areas, providing evidence of coherence.
Early STEM/Arts connection to early childhood literature	• A foundational component of the Wolf Trap Institute for Early Learning Through the Arts is the use of literature, both books and oral stories, as the content that inspires the use of arts strategies. Each summer institute included a block of time in which teachers would examine literature provided by the Wolf Trap project staff. They would review the entire selection of books set out on tables, identify a book, explore the story and identify the story that could be used to teach or link arts and mathematics, and share ideas about use of literature with colleagues and artists. In the PD institute binders, among the approximately 30 lesson plans, at least 10 grew from the elements of iconic stories, such as *Caps for Sale*; *Quillworker: A Cheyenne Legend*; and *Gorilla! Gorilla!*[vi] • Teachers identified and discussed mathematics content in stories and related the use of the literature to current curriculum, further demonstrating the emphasis on coherence. • These portions of the institute allowed teachers to be actively engaged in learning as they made selections of their training activities, participated in discussions, and presented their ideas.
Parent involvement	• In the PD institutes, the participants discussed approaches to involve parents in activities similar to ones their children were experiencing in class. In the first summer institute, the Wolf Trap project team introduced the parent component as a key element in the Wolf Trap approach and dissemination plan to teachers. In the 2012 summer institute, the returning Group 1 teachers met with a representative of the partner school district's district wide school-community office who introduced current district parent outreach activities and services. Teachers also had time periods to work with their teaching artists to describe ways they were already reaching out to parents, brainstorm ways to engage parents further, and develop specific strategies to do so in the coming year. Teaching artists reported that the parent outreach activities already developed by and with teachers included creating a newsletter and inviting parents to a demonstration of arts-integrated mathematics strategies. Teaching artists also noted ways to extend their planned lessons through activities that students and parents could do together at home.
Energizers	• Energizer activities lasting from 5 to 15 minutes were designed and delivered by teaching artists for all institute attendees each day. Each day began and closed with an energizer, and sometimes energizers were used as transitions during the schedule. The purposes of the energizer activities were to continue to illustrate arts-integrated activities in the performing arts disciplines, to demonstrate how performing arts could be used in transitions and to address social-emotional objectives. Energizers also accomplished the institute's goal of taking turns in leadership and active participation, bringing together all participants in one uniform activity, infusing physical activity into the day's schedule, and generally having fun. • In each energizer, teachers were actively engaged in using materials and

Institute Components	Description of Content and Identification of Key PD Features
	practicing activities that could be used in their classrooms.

Duration and collective participation. The Wolf Trap PD program included 101 hours of PD per teacher over two years (Table 3).

Table 3. *Duration: Planned Hours of PD per Teacher Over Two Years*

Activity	Hours/Unit	Number of Units	Total
Summer PD Institute in Year 1	6/day	4.5 days	27 hours
Summer PD Institute in Year 2	6/day	3 days	18 hours
Teacher meetings in Year 1	4/day	1 day	4 hours
Teacher meetings in Year 2	4/day	1 day	4 hours
Residencies in Year 1	0.75/visit	16 visits a semester × 2 semesters	24 hours
Residencies in Year 2	0.75/visit	16 visits a semester × 2 semesters	24 hours
Total (two-year treatment)	101 hours		

Wolf Trap sought to facilitate collective participation by opening recruitment to kindergarten and prekindergarten teachers at each participating school and encouraging them to participate together in the summer institutes. In some treatment schools, all recruited teachers participated together. However, in others, all teachers did not choose to participate; in some they did not attend the institutes together; and in some schools teacher attrition affected collective participation.

Records maintained by Wolf Trap of teacher participation in study activities indicate that the level of participation in PD events varied among treatment teachers. Of the 26 Group 1 treatment teachers, 14 participated in two full-year residencies and nine participated in 75% or more of the PD institute days. Twelve other treatment teachers participated in some activities for a part of a year or left at the end of one year. Wolf Trap created a one-day intensive makeup workshop for teachers who could not attend the summer institute and offered this in the fall before the residencies began.

Fidelity of Implementation

In this section, we report on the extent to which Wolf Trap PD program was delivered as planned and implemented with fidelity (RQ2). The Wolf Trap team first prepared artists for their work with teachers and then worked with artists to provide training at the summer PD institute. During the school year, artists provided coaching to teachers implementing Wolf Trap's approach in their classrooms. Each component of the PD is described below with respect to maintaining fidelity.

Training teaching artists. A planning year provided the key preparation for the artists. Teaching artists were first the students in the planning year and then co-planners of the summer institute. Teaching artists participated in 16 days of training during the planning year. Training sessions included presentations by early childhood mathematics specialists on the ways children learn mathematics and the mathematics content standards for prekindergarten and kindergarten students,

providing a knowledge base for the artists. With this foundation, teaching artists developed arts-integrated experiences with a variety of mathematics content topics. They presented these to their colleagues and the early childhood mathematics specialists for feedback and then refined the experiences. Over the planning year, the artists also worked in non-study schools piloting lessons and arts-integrated activities. To meet the capacity of two concurrent groups of teachers participating in the project, two additional teaching artists were trained in Year 2 of the grant. Training included a four-day institute, classroom residencies, and inclusion in ongoing working group meetings with their colleagues in the project.

PD Institutes. In each the implementation years (summer 2011, 2012, and 2013), Wolf Trap provided a summer institute. In the institute, teaching artists provided the majority of the instruction on content and strategies, and grant and foundation staff focused on topics such as the requirements of the grant, reporting, and data collection.

The institutes were slightly different each year because of the approach used to engage groups of schools in the study. The summer 2011 institute was delivered to Group 1 treatment teachers. PD activities included 4½ days of training (the institute) and a one-day intensive PD session for teachers who missed the institute was scheduled for the fall when teachers returned to school.

In summer 2012, the PD institute provided training for both Group 1 teachers (who would begin their second year of residencies) and Group 2 teachers (new to the program). Group 1 teachers participated in three days of institute activities, and Group 2 teachers participated in 4½ days of institute activities. In summer 2013, Group 2 teachers participated in three days of institute activities.

Residencies—Coaching by teaching artists. Classroom teachers in the treatment schools could participate in residencies each of two school years. In residencies, teaching artists work with teachers in a traditional cycle of coaching (i.e., plan, model, co-teach or teach, debrief), focused on the Wolf Trap approach of infusing arts-integrated strategies into mathematics instruction. The two-semester-long, 16-session residencies provided in each year included:

- Planning orientation and pre-residency meetings or classroom observations
- Ten classroom sessions led by the artist
- Co-planning meetings (two in the first semester and more in the second) during which teaching artists and teachers jointly created lesson plans
- Sessions led by the classroom teacher (two in the first semester, more in the second)

Teaching artists began the residency by leading arts-integrated experiences and worked to increase teachers' capacity to integrate arts and mathematics throughout the residency period, so that teachers would be leading these lessons during the school year. Each teacher was assigned to work with one teaching artist for one year. If the teacher remained in the study for two years, he or she would work with two different teaching artists.

When interviewed about their residency preparation and the two components of the PD, teaching artists noted that the planning year was vital, but that the work with teachers was most valuable. Artists found that the training for their role had some gaps in information (e.g., special education

instruction and content and focus in kindergarten). They also noted that the lesson plans, the main development activity in the planning year, were often revised to meet the needs in the classroom. Some artists noted that surprises regarding classroom pacing and grade-level focus led to new lesson development or, at least, adaptation. Some also noted that over time they developed a deeper understanding of, and comfort with, the mathematics standards and concepts. Teaching artists reflected very positively on the content expertise infused into their own training.

Research has indicated that the topics that may have the greatest value for coach preparation include the content, form, pacing, the role of the coach; familiarity with curriculum materials; skill in carrying out the elements of the coaching cycle; time management strategies; and skill in assessing student difficulties, among others. The relative importance of these may depend on the content of the coaching and the role of the coach (AIR, 2005). Preparation for the teaching artists included many of these topics.

To measure the fidelity of enacted residencies, we reviewed a sample of nine residency plans and 20 lesson plans selected from the plans created during the 2011–12 and 2012–13 residencies for the coverage of content, coherence, active learning, and evidence of the coaching model.

The residency plans contained a wealth of information about the goals that the artists and teachers created together; however, the information and coverage of all plan elements were not consistently detailed across documents. We also looked at the related lesson plans for alignment to the work that artists had done in preparing for the PD. The sample of plans we examined was not specifically linked to the plans in the PD binders, although many of the same skills and objectives were mentioned. We understood from interviews with the teaching artists that the work in preparing lesson plans during the planning year was a starting point, indicating that artists had adapted or built new plans. For example, regarding coverage of mathematics content areas, artists explained they did not try to cover all standards and topics: "Teachers explained what was needed regarding the standards. We did not take a general approach and try to cover four math areas in one residency, unless it was requested."

In all seven residency plans with detailed information, the artists reported a range of skill objectives for teachers. For example, they wrote in their plans that, by the end of the residencies, teachers would be able to use strategies such as teaching mathematics concepts through movement; using selected best practices for singing, movement, and storytelling with young children and creating and managing child-centered music, movement, and storytelling strategies that relate to curriculum objectives. All 20 of the lesson plans we reviewed confirm that teachers and artists planned to link arts and mathematics in their lessons and that they specified an arts skill to teach a mathematics concept. Teaching artists, when interviewed about their experiences in residencies, offered examples of topics they had covered. For instance, artists described covering mathematics topics such as measurement, "part part whole," and the value of money, as well as arts essentials and strategies such as choreography, role play, story dramatization, "coffee can theater," and music patterns that reinforce AB patterns. Two teaching artists described pacing content more slowly for special needs students. For instance, one explained that her special needs class covered shapes and patterning, whereas general education classes addressed more material and additional topics.

In our interviews, we asked all nine artists working with teachers in Group 1 about the strategies they used in their coaching, as well as whether they used a gradual release model. All nine teaching artists

interviewed indicated that their coaching included the gradual release strategies (model, co-teach, assist, observe, give feedback and debrief). One artist, for example, noted: "Yes, we did all that—I modeled, I cotaught, etc." Another artist told us:

> I talk to teachers about what the teacher and student needs are, and I try to work with teachers to create an art strategy that addresses those needs. Then I model the best practice [for delivering the arts-based math teaching strategies] and bring it to the teacher, and then they do it [deliver the strategies]; I pass it to the teacher.

From the teachers' perspective, the Wolf Trap project experiences were of value to their students and to themselves. When teachers responded to the 2012–13 year-end survey conducted by Wolf Trap, 85 percent strongly agreed or agreed with the statement "I will continue to use strategies and experiences I developed with the artist in the future." Teachers noted that the strategies they found most useful were "dramatizing stories and creative songs to teach and reinforce math concepts." Although most teachers (only two or three negative comments were documented as to the value of the PD for teacher and students) seemed to regard the participation as valuable, they expected a modest impact on student learning in mathematics.

Summary of Key Findings

RQ1: To what extent does the Wolf Trap PD represent the six features of high-quality PD identified in prior research?

Overall, Wolf Trap and the teaching artists delivered PD that exhibited the six features of high-quality PD—form, content, active learning, coherence, duration, and collective participation, qualified by the important consideration that not all eligible teachers from each school participated and not all recruited teachers participated for the entirety of the program. The role of the teaching artist was well defined and implemented as planned with support from content and pedagogy experts.

RQ2: Is the Wolf Trap PD implemented with fidelity? That is, does the Wolf Trap PD program (summer PD institutes and residencies) deliver PD that prepares classroom teachers to infuse performing arts–based strategies into their mathematics instruction, as intended?

As evidenced by the PD observations, residency plans and lesson plans, and artist interviews, the Wolf Trap PD program was implemented with fidelity and delivered preparation to teachers to infuse performing arts-based strategies into their mathematics instruction, starting in the PD institutes and then continuing in the residencies. The institutes followed the agenda as planned; the residencies followed the coaching cycle as planned; and the lesson plans were used to meet goals of content coverage, instruction, and arts integration. Wolf Trap used several approaches to optimize fidelity: a planning year and practice sessions with teaching artists, consistent use of local content experts, and materials structured to reflect the concepts and approaches used in both institutes and residencies.

Discussion

The Wolf Trap project team faced challenges in the design and implementation of the PD program. Many of these were resolved through a collaborative relationship with the district partner, a continuous improvement culture, and investment in the development of the teaching artists hired to work with the treatment teachers. The lessons learned and adjustments made can be useful to educators preparing to implement arts-integration programs. Our considerations in this area are consistent with other researchers' discussions of PD initiatives, which note that factors outside of a planned intervention may influence the quality and fidelity of implementation (Durlak & DuPre, 2008) and that institutional-, school-, and community-level elements—such as districts' arts standards, current PD for teachers, and schools' prior experience with arts—are important for arts-integration initiatives (Rabkin & Redmond, 2004).

Partnership With the District

The strong partnership with the study district in this grant contributed to successful implementation. The district research office provided guidance in submitting the required application to conduct the evaluation. District administrators actively supported dissemination of information to schools and teachers and recruitment of schools. The district early childhood administrators and content experts provided guidance and materials related to mathematics topics and sent district STEM coordinators to the summer institutes and advisory meetings. Language specialists from the district translated letters to parents about student participation in the study. The research office for the district provided the information needed for selecting students and used procedures to safeguard student identity. Some of these needs emerged as the project team faced recruitment and data collection milestones. Collaboration was established as a norm from the beginning of the proposal writing process and extended throughout the course of the project by providing opportunities to meet with district personnel and recognize the contributions of the district.

Preparation of Teaching Artists

Wolf Trap has a roster of performing artists conducting residency work with early childhood teachers. For this grant, the teaching artists participated in a grant-supported planning year and regular meetings at which they discussed teacher needs and implementation challenges. In the planning year, the teaching artists developed an understanding of the AEMDD project goals. The specialists and administrators from the partner district were included in the planning and development of preparation of teaching artists. With the participation of specialists, Wolf Trap prepared and presented content in the planning year, trying out lesson plans and preparing materials in anticipation of the agenda and activities for the summer institutes. Meeting with teaching artists during the planning year allowed identification of needs related to PD implementation, as summarized below. Most of these needs were addressed during the grant period, some specifically implemented in the summer institutes held in 2012 and 2013.

1. The artists suggested the training for the residencies and the PD institutes could incorporate observations of in-session classrooms (e.g., visiting summer school). This would give teachers and teaching artists the opportunity to discuss students' work in mathematics and to identify teacher practices before or while preparing their own lessons

and residency plans. This need has influenced Wolf Trap's continuing work through classroom piloting and teacher contributions.

2. Wolf Trap could invite additional experts to work with the artists to prepare them for the student populations they would work with, particularly special needs students and kindergarten students. The Wolf Trap PD included an introduction to research on mathematics learning; teaching artists recommended additional background and support for working with a variety of student populations. This need was addressed by Wolf Trap after it first emerged in artist feedback early in 2011. In response, Wolf Trap enhanced the content resources for teaching artists in their meetings; provided additional support in designing lessons for kindergarten and classrooms with children with special needs; and enhanced content coverage and exemplar activities in the summer institutes.
3. Wolf Trap could strengthen the early childhood pedagogy component of the PD by including it more explicitly. For instance, Wolf Trap could include in the binders a list of the pedagogy components (e.g., intentional questions) that were on whiteboards during the PD institutes, with definitions and examples of how to use them. These components were named and presented in the institutes to some extent, and they were included in Wolf Trap documentation. Wolf Trap could strengthen the coverage of this content by specifying these strategies and their research base, being explicit about the use of strategies, and offering practice and feedback on their use during the PD institutes. In later institutes, there was an increase in artist specificity about their instructional strategies.

Continuous Improvement Culture

Wolf Trap incorporated improvement-focused activities throughout the implementation years of the grant. For example, the project held mid-year meetings for teachers and teaching artists, maintained communication with district content experts, and sought feedback from an advisory group. As a result of these efforts, Wolf Trap's project team was able to revise the content and the format of the institutes in ways that better met the needs of the teachers and artists. For example, after the first PD institute, Wolf Trap gave teaching artists feedback that demonstrations would be improved if they were clearer about their objectives. For the second PD institute, the artists were explicit about the mathematics and arts objectives for each demonstration, and, in some demonstrations, artists provided interpretive commentary to help teachers process the content. In addition, teaching artists and teachers shared with Wolf Trap that kindergarten mathematics was more rigorous than expected and that refinement in some existing lesson plans would strengthen their applicability for the needs of teachers and students. In response, Wolf Trap delivered additional content to the teaching artists and guidance regarding the plans.

Limitations of Findings Presented in This Article

This article drew on data from an ongoing multiyear implementation and impact evaluation of the Wolf Trap AEMDD grant project. Findings presented in this article are based only on the experiences of 26 teachers in the first three treatment schools in Group 1. Group 2 teachers were still participating in the program while this article was being prepared. In addition to the small sample size, another limitation of the findings presented in this article is that these findings are all based on qualitative data about the features and the implementation fidelity of the PD, and do not address the

impacts of the PD on teacher practice and student achievement, which will be the focus of the final report of the larger evaluation. Further, this study focuses on teacher practice and does not measure teacher knowledge. It also does not measure student competencies other than mathematics knowledge that may be developing as a result of the PD program. Measures of those additional teacher and student outcomes would be helpful for program developers and evaluators.

Suggestions for Further Research

Several issues emerged for our own continuing work and for future research on arts integration.

1. The feedback from artists and teachers indicates that the residency itself was the primary vehicle through which teachers and artists worked to implement the arts-integrated strategies and activities. In the Wolf Trap model, the summer PD institutes were designed to build the knowledge base of teachers in the arts disciplines and the development of strategies meaningful for the grade and ability of the students. PD developers and researchers continue to debate the design of PD focused on teacher practices (Hill, Beisiegel, & Jacob, 2013). Further research needs to be conducted about the contribution of the summer institutes as a component of a comprehensive PD program.
2. In the Wolf Trap PD program, examples of arts-integrated strategies in action were observed; however, the creative process of linking the disciplines was not always visible. The literature indicates that more research is needed to address the methods and measures of arts-integration efforts (Herpin, Quinn, & Li, 2012; Horowitz & Webb-Dempsey, 2002). Furthermore, research has not fully explicated how teaching artists first understand the link between arts and other academic subjects and then use that knowledge to change teacher practices. Experts suggest building PD for artists on best practices in this area (Rabkin et al., 2011). Researchers may consider ways to isolate the process and the specific practices of arts integration.
3. We believe documentation maintained by artists (e.g., residency plans, lesson plans, debriefs with teachers, and description of arts-integration procedures) may be useful for providing insights into their role in helping teachers improve arts-integration. The use of artifacts for insight into practice is well known in studies of teacher assignments and student work (AIR & SRI International, 2004; Bryk, Nagaoka, & Newmann, 2000; Evan et al., 2006; Little, Goe, & Bell, 2009). There is a need for the development of rubrics for analyzing the artifacts from arts-integrated learning settings.

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[i] The content of this publication was developed under a grant from the Department of Education. However, this content does not necessarily represent the policy of the Department of Education, and endorsement by the federal government should not be assumed.

[ii] Since 1981, the Wolf Trap Institute has served hundreds of thousands of young children three months old through kindergarten, and their teachers, parents, and caregivers throughout the 17 national Wolf Trap Regional Programs (http://www.wolftrap.org/Education/Institute_in_your_Community/Regional_Programs.aspx) and other locations across the country. In the field of early childhood education, the Institute's approach is widely recognized as an effective model for direct instruction of children and embedded professional development for teachers. The Wolf Trap Institute's arts-based teaching method taps into children's innate desire for active, multisensory learning--as children literally embody concepts by singing and dancing--and engages their imagination through puppetry, story dramatization, and role play.

[iii] Throughout this article, we refer to Wolf Trap and its project team, which includes the grant director, the associate director for PD at Wolf Trap's Institute for Early Learning, specialists who routinely plan artist activities in multiple districts, the grant program assistants, and the teaching artists on contract to Wolf Trap for this grant. *Early Childhood STEM Learning Through the Arts* is the official name of the Wolf Trap grant project.

[iv] The PDIP survey has been used in a prior study conducted by AIR, which examined the PD delivered by Math and Science Partnership Projects funded by the National Science Foundation.

[v] The logic model and working model that emerged from the institute materials and observation notes is in the third tab of the PD Observation Form http://www.wolftrap.org/~/media/files/pdf/education/blank_2012_pd_obsvform.ashx.

[vi] *Caps for Sale* was written by Esphyr Slobodkina. *Quillworker: A Cheyenne Legend* was written by Terri Cohlene and illustrated by Charles Reasoner. *Gorilla! Gorilla!* was written by Jeanne Willis and illustrated by Tony Ross.