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Effectiveness of a Parent-Child Home Numeracy Intervention on Urban Catholic School First-Grade Students

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Catholic social teaching affirms the primary role of parents in their children's education, as well as the importance of forging a positive home-school partnership. The purpose of this article is to provide empirical evidence for further cultivating a collaborative, home-school relationship aimed at improving the mathematics performance of Catholic school first grade students by training parents as providers of at-home numeracy support. The participants included 60 parents (29 Black; 2 Asian; 1 Latino; 26 White; and 2 other) from two urban, Catholic schools. Parents randomly assigned to the experimental group received numeracy training and materials and, then, implemented a 15-week home numeracy intervention. Results revealed that students in the treatment group (or those who received the parent-child home numeracy intervention) made large and statistically significant gains in their mathematics achievement, measured by a standardized test, as compared to the control group.

Keywords

parental involvement, mathematics achievement, urban education, Catholic education

The mathematics achievement of all students continues to receive attention as educators and policymakers struggle to keep the United States competitive in the global economy. Policy reform emphasizing accountability and focusing on high standards has led to serious concerns about

the state of mathematics education in public and private schools (Chard et al., 2008; Crane, 2014; National Mathematics Advisory Panel [NMAP], 2008). Comparative analyses of nationally representative data sets revealed significant disparities in mathematics achievement between students attending Catholic and public schools (Carbonaro, 2006; Crane, 2014; Lubienski & Lubienski, 2006; NMAP, 2008; Reardon, Cheadle, & Robinson, 2009).

This research provided strong evidence that Catholic school students are falling behind their public school peers on mathematics assessments between kindergarten and fifth grade. Results from the Early Childhood Longitudinal Study, Kindergarten Cohort (ECLS-K) and National Assessment of Educational Progress (NAEP) datasets revealed that Catholic school students begin kindergarten at similar mathematics achievement levels as their public school counterparts (Carbonaro, 2006), lose the most ground between first and third grades (Reardon et al., 2009), and are about half a year behind public school students with similar backgrounds by the time they are in fifth grade (Crane, 2014; Lubienski & Lubienski, 2006; Reardon et al., 2009). Some possible explanations as to why Catholic school students are falling behind their public school peers include differences in school and class sizes (Borland & Howson, 2003; Milesi & Gamoran, 2006), teacher characteristics (Croninger, Rice, Rathbun, & Nishio, 2007; Reardon et al., 2008), school climate (Bryk, Lee, & Holland, 1993; Lubienski, Lubienski, & Crane, 2008), and parental involvement (Henderson & Mapp, 2002; Lee & Bowen, 2006).

Furthermore, this body of research casts doubt on the decades' old and commonly received belief that private schools are superior to public schools (Lubienski et al., 2008; Reardon et al., 2009). This assumption is especially problematic for Catholic schools, which are accountable to consumers and must strive to attract and retain students. At the national level, since 2005, Catholic elementary school enrollment has declined by 30% in the 12 urban dioceses and 20% in the rest of the US (McDonald & Schultz, 2014). This issue is severe in the northeast region of the US, where urban dioceses have seen up to a 35% decline in enrollment and the closing and merging of almost 30% of the Catholic elementary schools (Woodall, 2012). Given that early mathematics achievement is one of the best predictors of later academic success (Aubrey, Dahl, & Godrey, 2006; Aunio & Niemivirta, 2010; Baroody, Bajwa, & Eiland, 2009; Bodovski & Youn, 2011; LeFevre et al., 2009), Catholic educators and policymakers should consider implementing effective interventions during the early school years to improve Catholic school students' mathematics achievement.

A number of factors positively contribute to student achievement; foremost among them is early intervention (Aubrey et al., 2006; Chard et al., 2008; NMAP, 2008). Although a number of early childhood math programs have been developed over the past 15 years, the majority of these numeracy interventions were school-based, teacher- or researcher-delivered comprehensive curricula (see for example, Clements & Sarama, 2007, 2008) or supplemental activities on numeracy (see for example, Aunio et al., 2005; Dyson, Jordan, & Glutting, 2013). When considering the numeracy-learning environment at home, unfortunately and, too often, parents and primary caregivers charged with this task lack an understanding of the types of numeracy experiences needed by their preschool children (Muir, 2012). Consequently, children who do not receive at-home numeracy experiences enter school noticeably behind their peers and are highly susceptible to not only mathematics difficulties, but also a spiral of mathematics failure and frustration in successive grades (Baroody et al., 2009; NMAP, 2008).

This lack of early numeracy training is more prevalent in families in which parents have low levels of education. Though higher parental education predicts better student mathematics performance, it is speculative to conclude that this phenomenon is due to any difference in parents' educational values and their commitment to their child's school activities (Aunio & Niemivirta, 2010). Researchers (Aunio & Niemivirta, 2010; Hill & Craft, 2003; Tan & Goldberg, 2009) have agreed that it may relate to the complex interplay of parent involvement and other extraneous variables that need to be explicitly addressed in future studies. One way to disentangle such complex interactions and other influencing factors "might be to engage in specific interventions that systematically investigate the different ways parents could support their children's mathematical learning" (Aunio & Niemivirta, 2010, p. 432).

One area of untapped resources for Catholic education is involving parents to help their children learn numeracy at home, particularly because parents are seen as having a primary role in their children's education in Catholic schools (Code of Canon Law, 1983; Crea, Reynolds, & Degnan, 2015; Frabutt, Holter, Nuzzi, Rocha, & Cassel, 2010). Catholic social teaching affirms the role of parents as primary educators of their children and supports the need for a positive relationship between home and school (Code of Canon Law, 1983; Crea et al., 2015; Frabutt et al., 2010; Pontifical Council for the Family, 1983).

Research has also shown that school-aged children's mathematics achievement improves when strong school-home partnerships encourage

families to support their children's mathematics learning at home (Muir, 2012; Patall, Cooper, & Civey Robinson, 2008; Sheldon & Epstein, 2005). Given this research and the historically strong bond between Catholic schools and parents, a home-school partnership in which school personnel or researchers provide numeracy training to parents aimed at increasing student mathematics achievement is a plausible solution to the problem. Hence, this study investigated the effects of a parent-child home numeracy intervention that included numeracy training for the parents on the mathematics scores of first-grade students attending urban Catholic schools.

The purpose of this article is to provide empirical evidence for further cultivating a collaborative, home-school relationship aimed at improving the mathematics performance of Catholic school first-grade students by training parents as providers of at-home numeracy support. In the sections that follow, we first present background information on (a) parent involvement in early math learning; (b) parents' mathematics support and training; and (c) at-home numeracy training and intervention. We then trace a thorough description of our research methods before presenting and discussing the results and limitations of our study.

Parent Involvement in Early Mathematics Learning

Literature on children's early mathematics learning interchangeably uses the terms *numeracy*, *basic number skills*, *preparatory arithmetic skills*, *concepts of number and counting*, *number module*, and *number sense*. This study uses the term *numeracy* to refer to the skills that children acquire and display before and at the onset of formal schooling that are essential for learning mathematics in the primary grades (Aubrey et al., 2006; Aunio, Aubrey, Godfrey, Pan, & Liu, 2008; Aunio & Niemivirta, 2010; Bodovski & Youn, 2011; NMAP, 2008; Young-Loveridge, 2004). We define numeracy to encompass the mathematical knowledge and skills related to counting principles, number relationships, composing and decomposing of numbers, and landmark numbers (Aunio & Niemivirta, 2010; Baroody et al., 2009; Blevins-Knabe & Musun-Miller, 1996; Carpenter, Franke, Jacobs, Fennema, & Empson, 1998; Greenes, Ginsburg, & Balfanz, 2004; NMAP, 2008; Starkey, Klein, & Wakely, 2004; Young-Loveridge, 2004).

Educators and researchers generally agree that the cultivation of foundational mathematics knowledge and skills begins at home and in preschools, prior to children entering grade one (Aubrey et al., 2006; Aunio & Niemi-

virta, 2010; Blevins-Knabe & Musun-Miller, 1996; Bodovski & Youn, 2011; LeFevre et al., 2009; NMAP, 2008; Sheldon & Epstein, 2005; Starkey et al., 2004; Young-Loveridge, 2004). Fluency with basic number combinations begins with and grows out of the cultivation of number sense that emerges through parent-child shared home numeracy experiences (Aunio & Niemi-virta, 2010; Baroody et al., 2009; Hill & Craft, 2003; Tan & Goldberg, 2009).

Research has shown that children who do not develop and master numeracy skills by the end of first grade are less likely to experience mathematics success in subsequent grade levels (Aubrey et al., 2006; Aunio & Niemi-virta, 2010; Bodovski & Youn, 2011; Young-Loveridge, 2004). Research has also shown that school-aged children's mathematics achievement improves when strong school-home partnerships encourage families to support their children's mathematics learning at home (Muir, 2012; Patall et al., 2008; Sheldon & Epstein, 2005).

Researchers and educators believe parent involvement refers to a wide range of activities and connections among schools, families, and communities. According to Epstein (2001), schools typically support six types of parent involvement, ranging from helping families establish a supportive home environment for children and providing information to families about how to help students with homework and other curriculum-related materials to integrating resources and services from the community to strengthen school programs. As there are strong indications that effective forms of parent involvement are those in which parents work directly with their children on learning activities in the home (Cotton & Wikelund, 1989; Fishel & Ramirez, 2005; Houtenville & Conway, 2007; Lee & Bowen, 2006; Patall et al., 2008; Sheldon & Epstein, 2005), this study focused on providing information and ideas to families about how to cultivate numeracy skill development at home, which, consequently, will increase the overall mathematics proficiency of Catholic school students in grade one and beyond.

Parent Mathematics Support and Training

Mathematics is an intimidating subject for most parents, and many are unprepared to help their children (Kutner et al., 2007; Muir, 2012; Vukovic, Roberts, & Wright, 2013). When parents do not feel they have the skills necessary to help their children, parental frustration ensues (Hoover-Dempsey, Bassler, & Burow, 1995; Hyde, Else-Quest, Alibali, Knuth, & Romberg, 2006), which adversely affects the quality and quantity of the at-home

academic support (Cooper, Lindsay, & Nye, 2000). To add to this feeling of inadequacy, mathematics instruction has changed significantly over the years and is unlike that learned by most parents when they were school-age students. Consequently, parents have questions and concerns about how to best support their child's mathematics learning (Cotton & Wikeland, 1989; Litton, 1998). Parents need and desire additional support to enhance and sustain the effectiveness of their at-home involvement with their children (Epstein, 2001; Sheldon, 2003; Van Voorhis, 2011). Though less prevalent in schools, group-based parent training sessions are a viable, cost-effective, results-producing way to involve parents in their child's education (Cotton & Wikeland, 1989; Henderson & Mapp, 2002; Houtenville & Conway, 2007).

Research studies comparing parent involvement programs that include training components to those that do not, reveal that providing parental training enhances parent involvement (Cotton & Wikeland, 1989; Fishel & Ramirez, 2005; Patall et al., 2008). Patall et al. conducted a meta-analysis of experimental studies on the effects of training on parental involvement in homework for students in grades K–12 that revealed parent training has a significant, positive effect on (a) homework completion rates, and (b) accuracy, especially for the average elementary school student. Specifically, they found that students in grades two to five whose parents were trained to be involved in homework performed better than about 59% of students whose parents were not trained.

Patall et al.'s (2008) study also found that some types of parent training were more effective than others. In their study, they found positive effects when parents were trained to improve the home learning environment, help students improve homework habits, and supervise the homework process. This finding was similar to those of Sheldon and Epstein's (2005) study, which found that evening workshops and providing teacher-designed interactive homework and mathematics materials for families and students to use at home were more effective than other parent involvement activities. Synthesizing across the work of Cotton and Wikeland (1989), Litton (1998), Patall et al. (2008), and Sheldon and Epstein (2005), we found more effective parent involvement training can be achieved by: (a) providing written directions with a take-home instructional packet, (b) providing "make and take" workshops where parents construct materials and practice using them, and (c) providing programs whereby parents receive extensive training and ongoing supervision by school personnel.

At-Home Numeracy Training and Intervention

To our knowledge, only three studies have involved parents as providers of numeracy experiences for their primary grade children (LeFevre et al., 2009; Muir, 2012; Starkey et al., 2004), and none of these studies included children from Catholic schools. Using survey data from parents of 146 primary grade students, LeFevre et al. found a robust, positive relationship between the frequency with which children participated in indirect numeracy activities at home and mathematical proficiency. Indirect numeracy activities at home included parents' self-reported frequencies on doing activities that have quantitative components (e.g., board and card games, cooking, and shopping).

Muir (2012) investigated perceptions held by parents of children ranging from four to eight years old from two schools in Australia in relation to mathematics education and used an intervention program designed to encourage parents to engage in numeracy activities. The intervention program involved each child bringing home a "numeracy bag" containing their activity instructions, necessary materials and guidelines for parents, along with a short rationale explaining the purpose behind the activity. The expectation was that the child would engage in the activity two or three times a week with their parents, return the activity on Friday, and receive a new activity the following Monday. Muir found that parents were able to describe and evaluate their children's mathematical understandings. The findings add to the limited research available on the ways parents can support their child's mathematical education at home through home-school community partnerships.

More importantly, Starkey et al. (2004) investigated the effectiveness of a classroom-based and at-home numeracy intervention on the mathematics achievement of 163 prekindergarten children using the successive cohort design. They found that children who received the numeracy intervention scored significantly higher than those who did not, and those children from the middle- and low-SES groups benefited more from the intervention than those from the higher-SES group. Starkey et al. implemented a numeracy intervention that had a classroom and an at-home component. A home component was established to enable parents to support their children's numeracy development, because it was assumed that both the home and classroom environments are important in fostering children's early mathematical knowledge and more likely to provide for a successful transition from preschool to kindergarten. Parents attended a series of three mathematics classes over the course of the year where they learned how to engage their

children in unit-related activities. Additionally, the parents were given materials and curriculum guide sheets for conducting activities at home with their children (Starkey et al., 2004).

The Starkey et al. (2004) study provided preliminary evidence supporting the effectiveness of a combined at-home and at-school intervention for improving young children's mathematics achievement. Despite the combined promise of such an intervention and the positive home-school relationship present in Catholic schools (Code of Canon Law, 1983; Frabutt et al., 2010), the researchers have not been able to find studies that examined the effectiveness of an at-home numeracy intervention for Catholic school students in early grades. Informed by this review of literature and the seminal research design presented by Starkey et al., the researchers decided to conduct an experimental study on the effectiveness of an at-home numeracy intervention for urban Catholic school students in first grade.

Methods

A randomized control group pretest-posttest design was used, as it provided multiple strategies to control for potential confounding effects on mathematics achievement, including assessment of equivalence at pretest, random assignment, and controlling for pretest differences at posttest (Leedy & Ormrod, 2010). Sixty parents from two urban Catholic schools were randomly assigned to the treatment group and control group.

The two urban Catholic schools were located in the northeast region of the United States. Both schools provided a Catholic education for students enrolled in grades pre-K through eight, had two classes per grade level, and maintained a teacher-student ratio of at least 1:22 per class. Student population of School 1 contained all minority students (100%) and School 2 consisted of both majority (88%) and minority (12%). This notable difference in Catholic school demographics is typical within geographically expansive, urban Catholic school systems.

The context of first-grade math at these two schools was typical among urban Catholic schools, where: (a) school test data revealed that the students were not meeting annual mathematics proficiency standards; (b) schools used a common core-aligned mathematics curriculum, such as the Progress in Mathematics, approved by the Archdiocese; (c) classrooms were taught by certified and non-certified teachers and; (d) there was no aide in each class. We chose these two urban Catholic schools because their school administra-

tion and staff were actively seeking ways to increase the mathematics performance of their students, and school principals were eager and committed to logistically supporting the research project.

Intervention

Those in the treatment group received numeracy training and participated in the at-home numeracy intervention. The researchers provided two 90-minute training sessions with parents at the participating schools. During the first training session, the researchers explained the nature of the research project, discussed the importance of at-home numeracy development, and provided the parents with instruction and hands-on practice for cultivating numeracy in the home. During the second training session, the parents were given the opportunity to share their at-home experiences with other parents and to ask clarifying questions of the researchers. As part of the training, parents were instructed to engage their child(ren) in numeracy development activities four days per week for approximately 10 minutes per day as their at-home numeracy intervention. Parents in the treatment group were expected to engage in at least four weeks of at-home numeracy intervention to reach the minimum level of intervention fidelity. Parents were provided with materials to allow them to engage in up to 15 weeks of at-home numeracy intervention.

Approach. A constructivist approach and gradual release model of instruction was used to engage parents in numeracy education—both teaching and learning. Using a variety of materials (i.e., counters, place-value units and tens, 10 frames in contrasting colors, touch-point math for adding and subtracting, etc.), parents, in the role of their child, practiced activities aimed at developing counting principles, number relationships, and composing/decomposing numbers along with using landmark numbers when computing. Participating parents were instructed that the components of the home numeracy intervention were designed to be used in concert with each other, not in isolation.

First training. During the first training, parent participants were exposed to these numeracy skills. They learned the importance of verbal forward and backward counting by ones followed by skip counting by twos, fives, and tens to the targeted number specified in the draft version of the Pennsylvania Common Core Standards for Mathematics Contents and Mathematical Practice (Pennsylvania Department of Education [PDE], 2014). The re-

searchers showed parents how to develop their child's understanding of skip counting through the use of the concrete or "hands-on" materials provided to all participants. The second aspect of the intervention involved the use of pictorial representations of sets in the form of five- and ten-frame cards, dice, playing cards, and dominoes to cultivate counting principles, number relationships, decomposing and composing numbers, and landmark numbers (PDE, 2014; Siegler & Ramani, 2008). The third aspect of the intervention demonstrated to parents how to effectively use touchpoint counting to promote counting principles, number relationships, and computational efficiency. The majority of the parent practice time during the training was spent practicing the one-to-one correspondence associated with touchpoint math computation. The final aspect of the intervention introduced during the first training session involved the use of triangle flashcards to promote the composing and decomposing of numbers and computational automaticity.

Parents were instructed to engage their child in numeracy development activities four days per week for approximately 10 minutes per day or "for as long as it takes to suck on a Lifesaver." Furthermore, the researchers explained that all "take home" folders containing participant-maintained records of their child's work and any parent written communication, if developed, should be returned to their child's classroom teacher on the first school day of the week throughout the entire intervention period. Next, all materials needed by the parents prior to the second training session were provided along with the email address of the researchers, who were available to provide online consultation when requested. These materials included weekly parent-instruction pages, required math manipulatives, four student-practice pages per week, and a parent-reported child assessment questionnaire that included a space for parents to write comments and questions to the researchers. Lastly, parents were instructed to begin the intervention immediately.

Second training. During the second training session, the parents were given the opportunity to share their at-home experiences with other parents and to ask clarifying questions of the researchers. The researchers answered questions, reviewed content from Training Session 1, and then instructed the parents how to play several at-home numeracy-building games. These card and dice games were designed to develop children's skills involving counting principles, number relationships, and composing/decomposing numbers. After a final question-and-answer period, the parents were given the remainder of the materials needed to conduct the at-home numeracy intervention with their child. Prior to their departure, they were instructed to continue the

at-home numeracy intervention and to complete and return paperwork to their child's classroom teacher. Also, they were reminded that the researchers could be contacted via email, if necessary.

Data Sources

Participants. Parents from two urban Catholic schools participated in the study. Once written consent was obtained, volunteering parent participants (School 1, $n = 55$; School 2, $n = 50$) were randomly assigned to the control (School 1, $n = 30$; School 2, $n = 25$) and experimental groups (School 1, $n = 25$; School 2, $n = 25$) using a table of random numbers (Leedy & Ormrod, 2010). During the design and implementation phases of the project, the researchers collaborated with the school principals to create a parent-friendly intervention by offering trainings at dates, times, and locations convenient for the parents and providing refreshments and childcare. Moreover, the researchers were available to address any individual concerns and issues. Nevertheless, consistent with other research findings involving urban, at-risk populations, high levels of participant attrition ensued (Gross, Julion, & Fogg, 2001; Lee & Bowen, 2006). There was a 54% attrition rate for School 1 and a 60% attrition rate for School 2. Attrition occurred when (a) a parent agreed to participate in the study, but withdrew prior to the intervention (School 1, $n = 11$; School 2, $n = 10$); (b) a parent attended the first training session, but failed to attend the second training session (School 1, $n = 10$; School 2, $n = 7$); or (c) a student was present for the pretesting assessment session, but was absent for the posttesting session (School 1, $n = 4$; School 2, $n = 3$).

After accounting for participant attrition in this study, the sample population consisted of 60 parents (experimental group $n = 12$, control group $n = 48$) of first-grade students enrolled in two different urban Catholic schools within the northeast region of the United States (School 1, $n = 30$; School 2, $n = 30$). Table 1 shows participating parents' and students' demographic information for the treatment and control groups. A series of two-way chi-squares for independence (with Yates Continuity Correction) were conducted to determine if the control and experimental groups were significantly different on these demographic variables. Results revealed there were no significant differences on student gender, student ethnicity, parent income level, and parental education level between the participants in the control and experimental groups. Results also revealed no significant differences between the identified parent-level and child-level demographic variables between the

sample and the population, as well as between participants in the experimental group who remained and attritioned.

In order to provide additional validity for our study, we created a matched control group based on parental education to control for differences in this variable between the treatment and control groups. (See Table 1.) An additional series of two-way chi-squares for independence (with Yates Continuity Correction) showed that the treatment and the matched control groups were not statistically different on their child characteristics (gender and minority) and parental characteristics (e.g., household income and parental education) or school site.

Table 1

Participant Demographics

	Treatment (<i>n</i> = 12)	Control (<i>n</i> = 48)	Matched Control ^a (<i>n</i> = 21)
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)
Child Sex			
Female	11 (92)	45 (94)	19 (91)
Male	1 (8)	3 (6)	2 (9)
Child Race			
Minority	7 (58)	31 (65)	14 (67)
Nonminority	5 (42)	17 (35)	7 (33)
Household Income			
<\$40,000	3 (25)	30 (62)	11 (52)
\$40,000 to \$60,000	4 (33)	8 (17)	2 (10)
>\$60,000	5 (42)	10 (21)	8 (38)
Parental Education			
Up to high school	4 (33)	24 (50)	8 (38)
Up to associate degree	3 (25)	15 (31)	4 (19)
College and higher	5 (42)	9 (19)	9 (43)
Site			
One	4 (33)	26 (54)	11 (52)
Two	8 (67)	22 (46)	10 (48)

Note. ^aA matched control group was created to control for differences in parental education between the treatment and control groups.

None of the results from Chi-square tests on each demographic variable was statistically significant at the .05 level.

Implementation Fidelity

The researchers monitored implementation fidelity through several data sources: weekly parent-survey data and weekly student work that were available from the “take home” folders. Parents were expected to engage in at least four weeks of at-home numeracy intervention to reach the minimum level of intervention fidelity. Parents were provided with materials to allow them to engage up to 15 weeks of at-home numeracy intervention.

Weekly/biweekly parent-survey. The researchers monitored fidelity of the at-home numeracy intervention through the collection of the weekly/biweekly parent-survey data and the weekly student work. The parent-survey was designed to assist parents in assessing their children’s mathematics progress. The questions required parents to reflect upon their children’s performance/progress toward attaining the weekly/biweekly numeracy objectives. The average engagement level with the at-home numeracy intervention for the 12 parents in the treatment group was eight weeks, ranging from four weeks ($n = 7$), seven weeks ($n = 1$), and 15 weeks ($n = 4$).

Weekly student work. In training sessions and through individual communications with the researchers, parents were encouraged to adjust their instruction to meet their children’s needs. The collection of weekly student work samples provided the researchers with evidence of student performance and an auxiliary means of assessing student progress. The collected data provided rich contextual information for the researchers in their responses to parents.

Outcome Variable

Student mathematics performance was measured at preintervention and postintervention using the standard scores of the norm-referenced, Group Mathematics Assessment and Diagnostic Evaluation (GMADE™) Level 1, Forms A and B. Scores from the subtests: Concepts and Communication, Operations and Computation, and Process and Applications were used to calculate the Total Score.

Instead of relying on the typical teacher-made or textbook-produced mathematics test used in these schools, we chose to assess our outcome using GMADE Level 1. This norm-referenced test uses the standards set by the National Council of Teachers of Mathematics, including number and operations, algebra, geometry, measurement, and data analysis and probability. The test results were strongly predictive of TerraNova ($r = .85$) and ITBS® ($r =$

.90) scores (Williams, 2004a, 2004b). Level 1 was chosen as it was appropriate for first grade students.

We administered Form A at preintervention and administered Form B at postintervention to control for recall. In addition, to increase the reliability of the test scores across different sites, the same researcher who was trained in the administration of GMADE administered the test at both research sites. Table 2 presents the means and standard deviations on the pretest and posttest scores for the experimental group, control group, and the matched control group. The pretest scores for the subtests Concepts and Communication, Operations and Computation, and Process and Applications and the Total Test were comparable across the treatment, control, and matched control groups. The posttest scores for all three subtests and the Total Test for the treatment group were higher than both the control and the matched control groups.

Table 2

Mean and Standard Deviations on Pretest and Posttest Scores

	Experimental (<i>n</i> = 12)	Control (<i>n</i> = 48)	Matched Control ^a (<i>n</i> = 21)
	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)
Pretest			
Concepts	39.58 (15.27)	39.83 (14.05)	39.14 (15.41)
Computation	37.92 (18.63)	41.48 (16.38)	42.81 (14.54)
Applications	39.92 (17.91)	36.08 (18.70)	34.10 (18.65)
Total	34.33 (16.07)	34.79 (14.66)	33.95 (14.57)
Posttest			
Concepts	52.50 (15.59)	42.98 (16.85)	42.29 (15.87)
Computation	44.08 (17.84)	30.65* (19.58)	31.52 (23.88)
Applications	48.00 (12.45)	41.60 (16.05)	43.29 (17.03)
Total	45.67 (16.47)	32.17* (19.30)	33.05 (21.06)

Note. *Indicates the mean difference between the control and treatment group was statistically significant at the $p < .05$ level.

^aA matched control group was created to control for differences in parental education between the treatment and control groups.

We conducted the Pearson Product-Moment correlations between GMADE Total Test scores and the subtest scores (i.e., Concepts and Com-

munication, Operations and Computation, and Process and Applications) to see how correlated they were. The correlation coefficients ranged from .83 to .86 at preintervention and from .81 to .91 at postintervention, indicating that these scores were multicollinear and that only the Total Test scores should be used to determine differences between groups (Pallant, 2007).

Analysis

A one-way, between-groups analysis of covariance (ANCOVA) was conducted to determine the effect of the at-home numeracy intervention on the GMADE Total Test scores at postintervention, while controlling for the GMADE Total Test scores at preintervention (covariate). ANCOVA was conducted twice, once between the treatment and the control group, and a second time between the treatment and the matched control group.

Results

Results from Table 3 show statistically significant differences in the post-test total scores between the treatment group and both control groups, after adjusting for the preintervention GMADE Total Test scores.

Table 3

Analysis of Covariance Results

	<i>F</i>	η_p^2	<i>M</i> _{Treatment}	<i>M</i> _{Control}
Comparison 1				
Main Effect				
Group	8.59**	0.13	45.67	32.17
Covariate				
Pretest Total Score	38.30***	0.40		
Comparison 2a				
Main Effect				
Group	4.26*	0.12	45.67	33.05
Covariate				
Pretest Total Score	13.39**	0.31		

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

^aA matched control group was created to control for differences in parental education between the treatment and control groups.

Eta-squared, or percent variance explained, of .12 and .13 indicated large effect size (Cohen, 1988), demonstrating that students who received the at-home numeracy intervention made substantial gains on their post-test scores on the GMADE Total Test score. For instance, after adjusting for the preintervention GMADE Total Test scores, there was a significant difference between the experimental group and the control group on the GMADE Total Test score ($F(1, 58) = 8.59, p = .005$) with a large effect size (partial eta-squared = .13). Results also indicated a statistical significant difference between the experimental group and the matched control group on the GMADE Total Test score ($F(1, 30) = 4.26, p < .05$) with a large effect size (partial eta-squared = .12).

Discussion

The results of this randomized control group pre- and poststudy show that the use of parents as partners trained in providing at-home numeracy support is a viable means for increasing urban Catholic school students' early mathematics performance. The researchers found a statistically significant and large effect of the at-home numeracy intervention on the GMADE Total Test score for students included in the study. Findings extend current research in several ways and suggest areas where future research is needed.

First, findings provide Catholic educators with research-based evidence on how Catholic schools can partner with parents trained in providing at-home numeracy support to help improve urban Catholic school students' mathematics achievement. By providing at-home numeracy training to parents, Catholic schools will not only improve their students' mathematics achievement and chance for future academic success (Aubrey et al., 2006; Aunio & Niemivirta, 2010; Bodovski & Youn, 2011; Young-Loveridge, 2004), but they will also strengthen the parent-school relationship (Code of Canon Law, 1983; Epstein, 2001).

As assessed at the time of this research study, the use of parents trained in providing at-home numeracy support is virtually nonexistent in Catholic school communities. In addition to the benefits mentioned above, the cost of providing numeracy training for parents is minimal relative to the expense of introducing and implementing a new curricular initiative designed to increase the mathematical achievement of students. Undoubtedly, schools will experience problems associated with a lack of parent follow-through (Gross et al., 2001; Lee & Bowen, 2006), but they will also reap rewards when parents con-

sistently provide the at-home mathematics support needed by their children (Starkey et al., 2004).

Second, our findings provide additional empirical support of the type of parent-involvement training that includes the use of take-home instructional packets, provision for “make and take” workshops, and comprehensive parent-training programs supervised by school personnel (Cotton & Wikelund, 1989; Litton, 1998; Patall et al., 2008; Sheldon & Epstein, 2005). As schools are considering how to involve parents in helping their first-grade children with mathematics learning, they should be aware that provision of some type of parental training on numeracy will enhance parental involvement (Cotton & Wikelund, 1989; Fishel & Ramirez, 2005; Patall et al.). The researchers believe that the numeracy training provided participating parents a safe space to express their perceived challenges and concerns about numeracy and teaching numeracy, which may have reduced the intimidation and frustration parents typically experience related to mathematics (Hoover-Dempsey et al., 1995; Hyde et al., 2006). The researchers also believe that numeracy training provided participating parents sufficient knowledge and skills to be effective teachers at home for their children on issues relating to numeracy. Also, by asking parents to provide regular updates (i.e., through the weekly parent-survey data and weekly student work), the researchers were able to understand the types of issues parents were facing at home, and, in the process, improve the capacity to provide targeted guidance. The combination of these training components seemed to have empowered participating parents and made them successful at helping their child develop concepts and skills that promoted achievement in mathematics.

Third, this study adds to the small body of research on engaging parents as providers of numeracy experiences for their primary grade children (LeFevre et al., 2009; Muir, 2012; Starkey et al., 2004). The study extends LeFevre et al.’s survey research by showing that frequent and guided direct numeracy activities at home will lead to higher numeracy and mathematics proficiency. Likewise, this study extends Muir’s research by providing training to enhance parent effectiveness at providing numeracy education at home. Finally, it extends Starkey et al.’s investigation of a classroom and at-home numeracy intervention on prekindergarten children’s mathematics achievement by finding that first-grade students will improve on their mathematics achievement if there is an at-home numeracy component provided by parents who have been trained appropriately by school personnel.

Limitations

Typical of any intervention launched in an authentic setting such as a school (Gross et al., 2001; Lee & Bowen, 2006), the two prevalent limitations of this study pertain to the size of the sample population and attrition of study participants. First, our final sample size included 12 participating parents and children in the treatment group and 48 in the control group. Even with the low sample size and associated low power, the results indicated a large effect of the at-home numeracy intervention for children in the treatment group. This finding was confirmed when we compared the results between the treatment group and the matched control group. The sample for this study came from two urban Catholic schools in the northeast region of the United States. To the extent that these two schools are representative of other urban Catholic schools in the US, the results from this study are generalizable to other urban Catholic schools.

Second, there was a high attrition rate in the experimental groups. Prior studies have found that parents from urban, at-risk populations are often unable to commit the large amount of time required of intervention-based research, which consequently explains the associated high levels of parent attrition (Gross et al., 2001; Lee & Bowen, 2006). Knowing a high rate of attrition was likely, the researchers took a number of steps to make the at-home numeracy training and intervention meaningful for parents. During the design phase of the intervention, the researchers collaborated with the school principals to create a research protocol that would be highly parent-friendly. This included delivering the two trainings sessions at the recommended dates, times, and locations, and providing refreshments and childcare at these trainings. Moreover, the researchers helped parent participants set a limit to and manage the amount of time they engaged their child in the at-home numeracy activities. Parents were given the opportunity to share their at-home experiences with other parents and to ask clarifying questions of the researchers at the second training as well as by email. Even with these proactive actions to make this at-home numeracy intervention easier for parents, they were not enough to counteract the daily demands experienced by these typical, urban Catholic parent participants, which resulted in the high attrition rates of this study.

Future Research Needed

While this study provides strong support for early intervention and the involvement of parents trained in the development of numeracy skills, future research is needed to further substantiate and expound the results of this study. We recommend the replication of the current study with a larger number of parent and children participants at different levels of socioeconomic status and education levels. We also recommend future experimental studies to investigate whether there are different optimal levels of the at-home numeracy intervention for students from varying demographic backgrounds.

Secondly, thought should be given to conducting this study with kindergarten students as a proactive means of increasing the mathematics readiness skills of students entering grade one. This would necessitate adhering to the overall research design, while modifying the at-home numeracy intervention to comply with kindergarten-level numeracy standards.

Lastly, because this research study was limited to Catholic school students, this study should be replicated to include parents of first-grade students attending public and private, non-Catholic, schools. This would enable the researcher to determine the effects of the at-home numeracy intervention on the pre- and posttest scores of first grade students within and between school sectors.

Conclusion

Ensuring academic excellence and actively involving parents as partners in their child(ren)'s education has been a long-standing tradition of Catholic schools in the US. The current mathematics achievement gap between primary-grade students attending public and Catholic schools presents yet another opportunity for collaboration. In light of this strong home-school relationship, the use of parents as partners trained in providing at-home numeracy support, offers a practical means for addressing the mathematics achievement concerns confronting Catholic educators and policymakers. This study is among the first to provide research-based evidence on how such training could be implemented to meet the mathematical needs of urban Catholic school primary-grade students. The researchers believe that the most important benefit with regard to this type of training is the long-term implications for children's mathematics achievement and future mathematics success.

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