Developing Usable, Accessible, and Culturally Relevant Learning Materials to Support Parent-Child Interactions in Mathematics

Pooja Shivraj
American Board of Obstetrics and Gynecology

Leanne Ketterlin Geller
Southern Methodist University

Deni Basaraba
Bethel School District, Eugene, Oregon

Josh Geller
Southern Methodist University

Cassandra Hatfield
Southern Methodist University

Emma Näslund-Hadley
Inter-American Development Bank (IDB)

Abstract

Research indicates that parental involvement in children's education is positively related to academic achievement in mathematics; however, there are few studies on the role of parental involvement in the context of developing countries. The purpose of this paper is to document the iterative development using design-based research (DBR) of a home-based intervention intended to support parents' involvement with their children in mathematics within the Jamaican cultural context. Key components of the home-based intervention included (a) six sets of mathematics-learning materials, each covering foundational early mathematics concepts, and (b) educator-led workshops to support parents' understanding of the mathematics concepts. Four phases of the DBR process were implemented to create a usable and accessible intervention that was culturally relevant. These phases included (a) developing prototype materials using evidence-based practices and considering local contexts; (b) validating the prototype materials with focus groups comprised of multiple stakeholders; (c) evaluating the cultural relevance of the materials through external review; and (d) examining the feasibility of one set of mathematics learning materials through a small-scale study. Though not reported as part of this paper, we hypothesize that parents' involvement with their children will increase with the implementation of the intervention.

Keywords

home-based intervention; design-based research (DBR) methods; Jamaica; mathematics learning materials, early mathematics

Global Education Review is a publication of The School of Education at Mercy College, New York. This is an Open Access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC by 4.0), permitting all use, distribution, and reproduction in any medium, provided the original work is properly cited, a link to the license is provided, and you indicate if changes were made. **Citation: Shivraj, Pooja; Ketterlin-Geller, Leanne; Basaraba, Deni; Geller, Josh;Hatfield, Cassandra & Näslund-Hadley, Emma (2018). Developing usable, accessible, and culturally relevant learning materials to support parent-child interactions in mathematics. *Global Education Review*, *5* (3), 82-105.**

Supporting Parent-Child Interactions in Mathematics

According to the family support hypothesis, parents who actively participate in their child's schooling learn concepts, attitudes, and skills that can help them support their child's success in school (Miedel & Reynolds, 1999). Consequently, developing materials that parents can use in the home to support their child's mathematical understanding may reinforce concepts taught in school, remediate skill deficits, and assist students' achievement. The purpose of this paper is to describe the development of home-based intervention to support parents' involvement with their children within the Jamaican cultural context. We demonstrate how iterative development using design-based research (DBR) of a home-based intervention designed to support parents' involvement with their children in mathematics could produce an intervention that is usable, feasible, and culturally relevant.

The rationale for designing early elementary mathematics learning materials within a home-based intervention for parents in Jamaica was threefold. First, performance on the mathematics subtests of national exams in Jamaica revealed that the country's elementary students were not on track to meet the national goal set by the Ministry of Education of having 85% of all fourth-graders demonstrate mastery in numeracy by 2015 (Ministry of Education, 2011). Second, research across content areas, grade ranges, and countries suggests that parental involvement[1] is positively related to academic achievement (Fan & Chen, 2001; Gertler et al., 2014; Miedel & Reynolds, 1999). Third, surveys and assessments administered in Jamaica indicate that the level of parental involvement is low (Education Taskforce, 2004; Rattray & Lawson, 2011) and that Jamaican parents often do not perceive themselves as having the knowledge and skills needed to help their children academically (Munroe, 2009). The goal of this intervention was to address these issues by providing parents in Jamaica support through a home-based intervention that included mathematics learning materials and educator-led workshops. A brief synthesis of the research on the issues around parental involvement in children's education is described next, followed by an overview of design-based research (DBR) as a mechanism for developing culturally relevant materials for use by parents in a specific context.

Parent Involvement in Children's Education

Research across multiple content areas and grade levels has consistently demonstrated a positive relationship between parental involvement in children's education and children's academic achievement (Blevins-Knabe & Musun-Miller, 1996; Hill & Tyson, 2009; Munroe, 2009; Olatoye & Agbatogun, 2009). A study by Hart, Ganley, & Purpura (2016) examined the role of the home math environment (home activities which parents and children engage in that are intended to support math development) and a child's mathematics achievement for children ranging from ages 3 through 8. All data were collected through parent self-report. It was found that children of parents who reported doing more general mathematics activities at home, such as playing card games that use numbers, had higher mathematics skills; however, parents who reported doing more spatial activities, such as puzzles and building, had children with lower

Corresponding Author:
Pooja Shivraj, American Board of Obstetrics and Gynecology, 2915 Vine Street, Dallas, TX 75205.
Email: dr.pshivraj@gmail.com

Global Education Review is a publication of The School of Education at Mercy College, New York. This is an Open Access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC by 4.0), permitting all use, distribution, and reproduction in any medium, provided the original work is properly cited, a link to the license is provided, and you indicate if changes were made. **Citation: Shivraj, Pooja; Ketterlin-Geller, Leanne; Basaraba, Deni; Geller, Josh;Hatfield, Cassandra & Näslund-Hadley, Emma (2018). Developing usable, accessible, and culturally relevant learning materials to support parent-child interactions in mathematics. *Global Education Review*, *5* (3), 82-105.**

mathematics skills. It is worth noting, however, that the majority of research conducted in this area was with preschool-aged children (Anders et al., 2012; Blevins-Knabe & Musun-Miller, 1996; DeFlorio & Beliakoff, 2015; LeFevre et al., 2009) and that little work has been done to investigate the impact of parental involvement with children in the primary grades (Fan & Chen, 2001; Jordan, Kaplan, Nabors-Olah, & Locuniak, 2006).

Moreover, much of the research conducted examining the impact of parental involvement on children's academic outcomes (generally, or on mathematics outcomes specifically) was conducted in Western countries where a variety of educational supports are already available for students (Anders et al., 2012; Blevins-Knabe & Musun-Miller, 1996; Hill & Tyson, 2009; Jordan et al., 2006; LeFevre et al., 2009; Munroe, 2009; Musun-Miller & Blevins-Knabe, 1998; Olatoye & Agbatogun, 2009). Significantly less research on the effectiveness of this type of intervention has been done in developing countries like Jamaica (Powell, 1999). This paper aims to begin addressing this gap in the literature by describing the iterative process of developing mathematics learning materials for use by Jamaican parents at home to support the mathematics learning of their first and second grade students.

Encouraging Parental Involvement

Providing parents with structured opportunities to support their children's mathematical learning at home is important because parents spend more time at home with their children building literacy skills than mathematics-related skills (Blevins-Knabe & Musun-Miller, 1996; Jordan et al., 2006; LeFevre et al., 2009; Musun-Miller & Blevins-Knabe, 1998). Although multiple types of parental involvement are related to students' academic performance (Epstein, 1994), research indicates that activities in which parents work *directly*[2] with their children in the home may be the most effective form of parental involvement (Cotton & Wikelund, 2005).

The importance of encouraging parents to work directly with their children in the home was recently demonstrated in Jamaica by Munroe (2009), who sought to identify issues and concerns that may influence parental involvement in education in Jamaica, to subsequently identify solutions that may help increase parental involvement. To do this, Munroe explored the relative contribution of parents' motivational beliefs, perception of invitations of involvement from others, and perceived life context to their level of involvement in their children's education. Application of this model revealed that although parents were interested in increasing their level of involvement in their children's education, schools needed not only to improve parents' knowledge and understanding of the concepts their children were learning, but also to "provide specific guidance and instruction on developmentally appropriate parental involvement strategies and opportunities for parents to be engaged" (Munroe, 2009, p. 231). The need to provide parents with guidance and strategies on how to support their child's learning at home has been observed in studies conducted in multiple cultural contexts, specifically with Latinos (Lopez & Donovan, 2009) and with Finnish parents (Silinskas et al., 2010). To design a home-based intervention to be responsive to the needs of Jamaican parents and reflective of the Jamaican cultural context, we designed our intervention using design-based research (DBR) as the underlying framework. This is described in more depth next.

Design-Based Research and Importance of Methodologies that Consider Local Context

Design-based research (DBR) methods provide a valuable opportunity for researchers to collaborate with practitioners and end-users (e.g., parents) to create meaningful changes during the process of intervention design, development, implementation, and evaluation (Anderson & Shattuck, 2012; Cobb, diSessa, Lehrer, & Schauble, 2003; Design-Based Research Collective, 2003). DBR presupposes synergistic relationships among research, design, and development in real-world contexts, such as schools or children's homes. The process creates a mutually beneficial relationship that allows researchers to solicit input and feedback from those responsible for implementing the intervention by engaging users in defining the problem, identifying solutions, observing the intervention, addressing any problems and/or needs, and in identifying why and how adjustments should be made to the proposed intervention (Wang & Hannafin, 2005). Because end-users of the intervention participate in the development process, they have opportunities to provide feedback and suggestions for improving the intervention and recommendations for contextual changes that may increase ease of implementation.

Incorporating end-user feedback was especially important for this project because the home-based intervention was designed for a specific context. Designing an intervention for use within a specific context requires consideration of the cultural relevance of the materials (Wang & Hannafin, 2005). Cultural adaptation is a process that involves systematically modifying materials to consider the language, culture, and/or context of the target population so as to create materials that are compatible with the end-users' practices, beliefs, and real-world experiences (Cardona et al., 2012). Bernal and Saenz-Santiago (2006), for example, recommended culturally adapting evidence-based materials and practices to impact specific areas of implementation, by using appropriate methods of intervention delivery, linguistic appropriateness of curricular materials, and understanding of the local context within which the materials will be implemented.

DBR served as a central framework for guiding the iterative development of the culturally-relevant home-based intervention through four key phases: (a) developing prototype mathematics learning materials, including the development of culturally appropriate storybooks and games/activities that would allow us to solicit input from end users; (b) validating the prototype materials with focus groups comprised of multiple stakeholders to allow them to identify issues with the materials and potential solutions to address the issues; (c) evaluating the cultural relevance and mathematical accuracy of the materials through external review by experts; and (d) examining the feasibility of one set of mathematics learning materials through a small-scale study with a sample of parents. Combined, these phases allowed us to determine if the home-based intervention was usable, feasible, and culturally relevant to parents and their children as a way to gain end-user perspective. This iterative development framework can be seen in Figure 1, where the cyclical refinement process across the last three phases is represented by the double arrows. After each phase, the mathematics learning materials and educator-led workshops within the home-based intervention were refined to improve their usability, accessibility, and relevance for parents and their children.

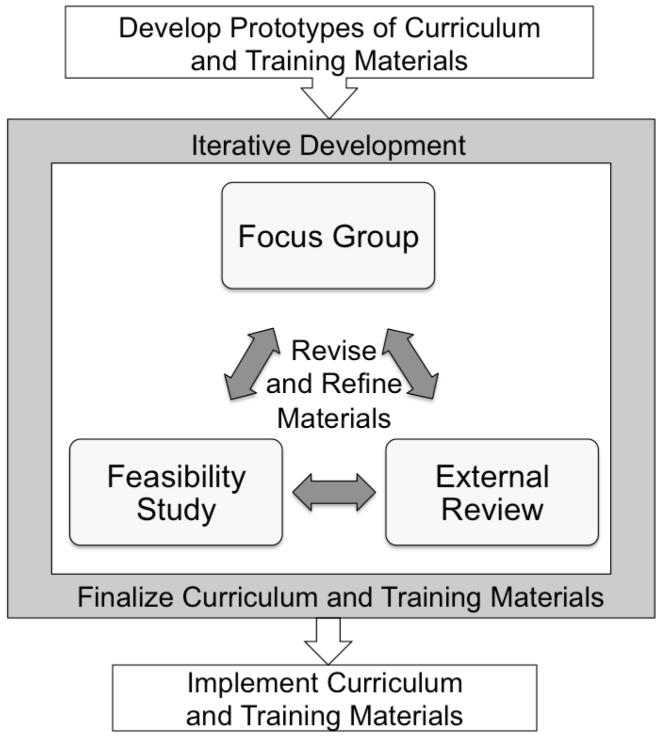


Figure 1. Iterative development of the mathematics learning materials within the home-based intervention.

Development of the *Prototype* Home-Based Intervention

The home-based intervention described in this paper was designed to support parents' involvement and interactions with their children in mathematics in Jamaica. It included two components: (a) six sets of mathematics-learning materials covering foundational early mathematics concepts, and (b) educator-led workshops to support parents' understanding of the mathematics concepts. Each of the six mathematics learning materials included (1) an overview of the targeted mathematics concept, (2) one or more mathematics games, (3) a storybook that incorporated mathematics questions, and (4) explicit connections between the mathematics concepts and the home environment. An educator-led workshop accompanied each set of mathematics learning materials to teach parents how to use the materials. The main objectives of these workshops were to provide parents with (a) conceptual understanding of the target mathematics content (one mathematical concept or skill for each workshop) and (b) an opportunity to practice using the mathematics learning materials with each other before interacting with their children.

The home-based intervention was based on theoretical principles of mathematics learning that support the development of mathematical knowledge in children and adults alike. In addition, we incorporated evidence-based practices to make the mathematics learning materials and educator-led workshops

Global Education Review is a publication of The School of Education at Mercy College, New York. This is an Open Access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC by 4.0), permitting all use, distribution, and reproduction in any medium, provided the original work is properly cited, a link to the license is provided, and you indicate if changes were made. **Citation: Shivraj, Pooja; Ketterlin-Geller, Leanne; Basaraba, Deni; Geller, Josh;Hatfield, Cassandra & Näslund-Hadley, Emma (2018). Developing usable, accessible, and culturally relevant learning materials to support parent-child interactions in mathematics. *Global Education Review*, 5 (3), 82-105.**

maximally useful, accessible, and relevant to parents and their children. The design principles underlying the development of the prototype home-based intervention are described next.

Foundations of Mathematics Proficiency

Given that elementary students in Jamaica were not on track to meet the national goal set by the Ministry of Education (Ministry of Education, 2011), we organized the mathematics learning materials around the "three critical prongs of mathematical proficiency" identified in Jamaica's National Comprehensive Numeracy Programme (Ministry of Education, 2011, p. 24). Those prongs are (a) conceptual understanding, (b) procedural fluency, and (c) problem-solving and strategic reasoning. Each set of materials was also aligned with one of six core early numeracy concepts (i.e., making tens, multiples of ten, etc.) that reflected the Ministry of Education's priorities, and matched the topics taught during the academic year.

Conceptual Understanding

Conceptual understanding can be defined as knowledge that facilitates understanding of the interrelationships between concepts or pieces of knowledge within a domain (Rittle-Johnson & Alibali, 1999). Rather than focusing on the awareness and understanding of isolated mathematics skills and processes, conceptual understanding refers to flexibility in mathematical thinking that enables the thinker to represent mathematical situations in multiple ways (with the understanding that different representations may be useful for different purposes) and knowing how various representations are similar, different, and related (Hallet, Nunes, & Bryant, 2010; Kilpatrick, Swafford, & Findell, 2001).

Procedural Fluency

Procedural fluency refers to "knowing how" to do something—often how to follow a sequence of steps or actions to solve a problem (Hallet et al., 2010; Rittle-Johnson & Alibali, 1999). Procedural fluency has also been defined more broadly as knowing mathematical procedures, knowing when and how to use them, and possessing the skills to perform them flexibly, accurately, and efficiently (Kilpatrick et al., 2001).

Integration of conceptual understanding and procedural fluency supports overall mathematical proficiency. For example, when learning the concept of number, students who thoroughly understand critical concepts (such as place value) and are skilled in procedures (such as operations with single-digit numbers) can extend their understanding to new areas, such as operations with multi-digit place numbers (Kilpatrick et al., 2001). Designing learning opportunities that integrate concepts and procedures helps students learn important mathematical skills efficiently, reason about the plausibility of their responses, communicate about mathematical concepts, and develop a deeper level of proficiency.

Problem-Solving and Strategic Reasoning

Strategic competence—or the ability to identify, formulate, represent, and solve mathematical problems (Kilpatrick et al., 2001)—requires not only conceptual understanding of the mathematics behind a given problem, but also accurate knowledge of the sequence of action needed to solve the problem. To be successful problem-solvers, students must be able to understand the problem situation and then develop a mathematical representation that can be used to solve it. This process involves multiple skills and strategies, including distinguishing relevant from irrelevant information (de Jong et al., 1998; Heinze, Star, & Verschaffel, 2009).

These elements of mathematical proficiency were integrated directly into the mathematics learning materials and the educator-led workshops for parents.

Evidence-Based Practices (EBPs)

We incorporated evidence-based practices in mathematics education into both components of the home-based intervention. These practices included explicit and systematic instruction, use of visual representations, game-based learning, and the inclusion of literacy activities. In addition, instructional design principles to improve accessibility were integrated into the development of the intervention.

Explicit and Systematic Instruction

Because the majority of parents were not teachers and likely have not received any training on effective, evidence-based strategies on how to support their children's learning they would be likely to benefit from specific guidance on how to support their children's learning at home (Silinskas et al., 2010; Lopez & Donovan, 2009). To address this need, we incorporated principles of explicit instruction into the design of the intervention with the intent of providing a consistent structural framework throughout the material so that the delivery of the mathematics concepts would remain relatively constant even as the content increased in mathematical complexity. To support successful modeling of task completion we incorporated scaffolded examples and opportunities for parents to practice with their children. In an effort to minimize confusion and maximize understanding we included clear, mathematically precise and consistent language to introduce, describe, model, and review the foundational mathematics concepts within the context of the home-based activities. To reinforce for parents and children that mathematics is not only about "getting the right answer," we included questions to extend children's thinking and provide them with opportunities to verbalize their mathematical thinking and understanding, a strategy found to be positively related to mathematics success (Gersten et al., 2009). In addition, highly scripted training materials were included so educators could lead workshops and support parents' conceptual understanding of mathematics concepts while delivering workshops with fidelity.

Visual Representations

Visual representations such as manipulable models, pictures, diagrams, and tables can be an effective tool for supporting mathematically focused activities and discussions between parents and children because they make abstract mathematical concepts more tangible and comprehensible (Flores, 2002; Gersten et al., 2009). Results from a meta-analysis of instructional design features that support students' learning found that visual representations have a moderate positive effect (mean $g = 0.47$) for supporting students' mathematical thinking and understanding (Gersten et al., 2009). For example, to support understanding of the numbers that combine to make 10, a "tens frame" (i.e., 0+10, 1+9, 2+8, etc.), can be used as both a model and a diagram to support student learning.

The benefits of using visual representations include: (a) supporting students' ability to make sense of and reason about mathematical concepts and tasks, (b) helping students to organize and share their thinking and to construct mental models of mathematical ideas, (c) making abstract mathematical concepts more tangible, and (d) strengthening students' understanding of the connections between procedures and concepts or between various mathematical strategies (Mitchell, Charalambous, & Hill, 2014). Visual representations are often incorporated into board games that may be found in the home, such as the number path in *Chutes and Ladders*. Following this example, the mathematics learning materials developed for the home-based intervention incorporated visual representations such as a number path, tens frame, and hundreds chart whenever possible.

Game-Based Mathematics Learning

Engaging games can be used to support formal and informal mathematics learning by increasing the time children spend working with mathematics outside of school. In a qualitative study, Park, Chae, and Boyd (2008) observed that block play supported children's ability to learn complicated mathematics concepts and engage in complex thinking in a school context. Playing number games (linear-number board games, in particular) helped students develop a range of mathematical skills, including familiarity with numbers, numerical estimation skills, and multiple representations of numbers (Ramani & Siegler, 2008; Whyte & Bull, 2008). Young-Loveridge (2004) found significant effects on young children's numeracy skills after an intervention that included playing mathematics games and reading mathematics-related storybooks. For the games, the researcher included games in which the outcome was determined by chance (e.g., by rolling dice). She hypothesized that this chance element may have enhanced children's interest in the game.

Since game-based learning has been shown to support parent engagement and involvement (Ramani & Siegler, 2008; Thompson, Gillis, Fairman, & Mason, 2014), we integrated games into the mathematics learning materials including bingo, dice games, number-path games, and card games. Whenever possible, the elements of chance and competition among players were built into the game. Game boards and directions were provided, and game pieces included readily available materials (e.g., pebbles, beans, etc.).

Integrating Mathematics and Reading

Empirical studies of the relationship between mathematics and literacy indicate moderate, positive correlations between the two constructs as early as preschool (Purpura, Hume, Sims & Lonigan, 2011; Purpura & Napoli, 2015) and throughout the elementary and secondary grades (Adelson, Dickinson, & Cunningham, 2015). Results of a recent study in which a dialogic reading intervention explicitly focused on quantitative and spatial mathematics language, revealed significant positive gains in children's acquisition of mathematical language and significant improvements in their general mathematics skills (Purpura, Napoli, Wehrspann, & Gold, 2017). Similar to much of the research focused on parental involvement, the majority of research conducted to-date investigating the relations between literacy and mathematics has been conducted in the United States. Consequently, the current study affords an opportunity to explore the role of mathematical storybooks promoting mathematics learning in a new context.

Because many parents are more at ease with reading than mathematics (Anders et al., 2012), weaving mathematics concepts into storybooks may provide parents with a familiar structure for engaging with their children in mathematical thinking. Mathematics books for young children often focus on critical mathematical concepts such as counting, cardinality, and place value. Similarly, integrating mathematics into reading activities provides parents with an opportunity to focus explicitly on mathematics vocabulary that is often more abstract (Shanahan & Shanahan, 2008) and provides children with opportunities to practice deriving meaning from other sources beside text, such as figures, graphs, and tables. Moreover, frequently and purposefully integrating mathematics and reading can help children understand that the two tasks are not necessarily separate and distinct.

Because of the positive relation between reading and mathematics performance (Purpura et al., 2017), we also included a storybook with mathematics learning materials. Each storybook included embedded mathematics questions that related to the storyline (e.g., a story about football might ask questions about the number of total goals scored by both teams).

Two additional approaches were implemented to design accessible and relevant learning materials to promote parental involvement: (a) integrating principles of universal design for learning (UDL; Center for Universal Design, 2007), and (b) ensuring the cultural relevance of materials.

Universal Design for Learning

UDL is based on the premise that learning materials can be made more accessible for the target population by carefully weighing their needs when developing the materials (Rose, 2000). CAST (2011) proposed a series of guidelines for applying UDL to the design of learning materials that promote equitable use, a UDL principle that we embraced in our work. The CAST guidelines promote flexibility and adaptability of the materials to various users' needs.

We incorporated the principles of UDL to design mathematics learning materials that would be maximally useable and accessible by parents when working with their children. For example, to support parents with varying levels of literacy, all mathematics learning materials included pictorial as well as verbal directions. We also included activities that could be adapted to the mathematical skill levels of parent and child (e.g., increasing or decreasing complexity). To make the materials simple and intuitive to use, we incorporated everyday objects (e.g., beans, rocks) into the games and provided models for successful completion of the activities (e.g., how to spin a spinner and use the spinner to determine how many spaces to move a token along the number path). To ensure that information was readily comprehensible, we relied on varying presentation modes and formats (e.g., pictorial, verbal, tactile) and included clear, mathematically precise, and consistent language to introduce, describe, model, and review mathematics concepts.

Table 1 illustrates four UDL principles, several of the proposed guidelines, and how we addressed these guidelines in the development of the mathematics learning materials and educator-led parent workshops.

Table 1.
Methods for incorporating UDL principles in mathematics learning materials

Principle	Guidelines	Examples of incorporation of UDL in materials
Principle 1: Equitable use	Offer all users the same means (identical or equivalent materials)	Parent handouts, children's learning materials, and children's activities/games were all designed identically.
	Use an appealing design	Parent handouts, children's learning materials, and children's activities/games included engaging illustrations, manipulatives, and low levels of text density. In addition, games were revised to be less like homework and more engaging.
Principle 2: Flexibility in use	Adapt to user pace	Parents were able to work at home with their children at whatever pace was needed to enable their children to master the targeted concepts. Storybooks had questions at various levels to allow parents to adapt to the child's math ability.
	Accommodate right-handed and left-handed users	Manipulatives in activities/games were designed for ambidexterity, such that they could be used by participants who were left- or right-hand dominant.
Principle 3: Simple and intuitive use	Accommodate a wide range of literacy skills	All materials (training materials, activities/games) were designed with attention to word density and to ensure that literacy challenges did not introduce a source of variance irrelevant to the mathematical construct being taught. Children's storybooks were written taking into consideration word count and grade level.
	Arrange information by importance	All materials were designed such that the basic understanding of the task/concept would be established prior to building fluency in performing the task. For example, parents established a conceptual understanding of the mathematics before playing the game and answering questions posed in the storybook.
	Provide feedback and prompting after task completion	Workshops included questions parents could ask during and after the games to check for understanding, as well as guidelines for providing useful and meaningful feedback.
	Eliminate complexity	We made the activities as explicit and easy to understand as possible (while still focusing on challenging mathematics content).
Principle 4: Perceptible information	Use different modes of presentation (pictorial, verbal, tactile)	Parent workshop materials incorporated visual, verbal, and tactile presentations of content, as well as opportunities for parents to record salient information.
	Maximize legibility of information	Key words and phrases were bolded to make them easy to read. All text was presented in legible typefaces.
	Differentiate elements in ways that can be described (i.e., make it easy to give instructions or directions)	Activities/games distinguished between what parents were supposed to say before the activity/game (instructions), questions they could ask during the game, and specific feedback they could provide to their child.

Cultural Responsiveness and Relevance

A culturally relevant curriculum is one "that empowers students intellectually, socially, emotionally, and politically by using cultural referents to impart knowledge, skills, and attitudes" (Ladson-Billings, 1994, p. 382). Using culturally relevant texts and materials that incorporate aspects of students' life experiences can improve students' reading comprehension by activating prior knowledge (Anderson, 1994; Carrell, 1987; Hickman, Pollard-Durodola, & Vaughn, 2004). To promote the acceptance and relevance of the mathematics learning materials developed for this project, we incorporated relatable and familiar aspects of Jamaican families' daily lives, such as idiomatic language, extracurricular interests (such as music and sports), and cultural icons and customs (such as major festivals). We provide illustrative examples of some of these revisions we made based on feedback from stakeholders later in the paper.

Focus Groups: Revising Prototype Learning Materials to Increase Usability, Accessibility, and Relevance

Following the development of prototype mathematics learning materials, we engaged in a cyclical refinement process comprised of three steps as shown in Figure 1. The first phase involved soliciting input from stakeholders on the prototype materials through focus groups. According to Krueger (2009), focus groups are a viable methodology for collecting information that informs program development and decision-making. Conducting focus groups at different points in the development of a product or program may serve a variety of purposes: (a) to gain an understanding about how the target population understands and values a particular topic; (b) to pilot-test prototypes created based on the information obtained during the focus group; and (c) to evaluate the effectiveness, usability, and/or feasibility of a product after it has been developed (Kreuger, 2009). The use of focus groups integrated well into the DBR framework because it provided an opportunity for researchers to collaborate with end-users during the process of design and development of the mathematics learning materials to gather meaningful and iterative feedback that could increase ease of implementation.

We conducted six focus groups targeting different stakeholders including (a) staff of the Ministry of Education, (b) curriculum developers, (c) teachers, (d) parents and caregivers, (e) community leaders, and (f) members of local advocacy groups. The purpose of these focus groups was to help us gain a better understanding of the Jamaican education system and culture, and to gather information to support the development of home-based intervention to be culturally relevant and respectful.

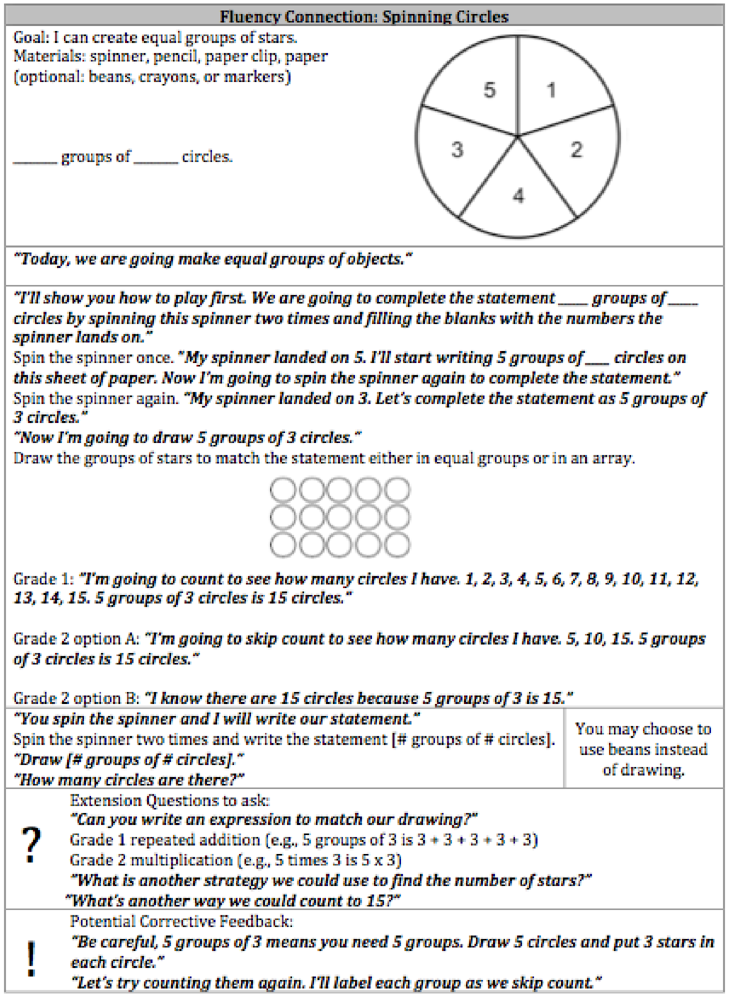
The primary goal of the focus groups was to hear the stakeholders' views on the usability, accessibility, and relevance of the prototype learning materials. Specifically, given the generally low rates of literacy within the target population, we solicited stakeholders' input about the accessibility of the materials for parents, the cultural relevancy of the games for Jamaican families, the ease with which the materials could be implemented and disseminated among parents, and other cultural considerations that might influence the usability and utility of the materials for parents with their children at home. All six focus groups were conducted by members of the research team; each lasted 1–2 hours. Field notes and audio or video recordings were obtained and subsequently analyzed for themes by one member of the research team and verified by other members who participated in the focus groups.

We received specific feedback about the components of the home-based intervention, and additional themes emerged during the focus groups. When demonstrating the game, the feedback received was constructive. Concerns were raised about the significant amount of text and the use of extensive scripting, specifically using “teacher-speak” as opposed to language parents would use with their children. For example, stakeholders suggested replacing “*What is another strategy?*” with “*Show me another way*.” Participants in one focus group observed that the game looked like homework because it required paper to draw. Although they saw the benefit of the activity, they thought that parents in the target group (a) might not be able to follow along, given the substantial amount of text, and (b) might feel uncomfortable and anxious implementing the activity with their children owing to the reading and writing skills required. Participants suggested using common items found in and around homes (e.g., beans, rocks) to decrease the game’s similarity to schoolwork and to make it more accessible. Stakeholders observed that the prototype games lacked the cultural relevance needed for parents to be fully engaged and enthusiastic about implementing them with their children. For example, the prototype mathematical game did not reflect typical game play since it required using paper and pencil.

Although the prototypical game was designed using the principles of UDL, we further considered how to increase the usability of the materials based on the feedback, and reconceptualized the instructions to make them more simple and intuitive to use. The prototype mathematics game was revised, as can be seen in Figure 2. For greater accessibility of materials and relatability of language, we revised the directions for conciseness and added visual representations to help guide all parents, regardless of literacy level. We also provided parents with dice to play the game. To make the game appear less like homework and to increase engagement and enjoyment, we revised the game to make it more competitive, “game-like”, and reflective of typical game play. These recommendations were applied to all of the mathematical games created for the project.

Before	After
Prototype mathematics game before focus groups	Revised mathematics game after focus groups

Before:



Fluency Connection: Spinning Circles

Goal: I can create equal groups of stars.
Materials: spinner, pencil, paper clip, paper
(optional: beans, crayons, or markers)

_____ groups of _____ circles.

"Today, we are going make equal groups of objects."

"I'll show you how to play first. We are going to complete the statement ____ groups of ____ circles by spinning this spinner two times and filling the blanks with the numbers the spinner lands on."
Spin the spinner once. ***"My spinner landed on 5. I'll start writing 5 groups of ___ circles on this sheet of paper. Now I'm going to spin the spinner again to complete the statement."***
Spin the spinner again. ***"My spinner landed on 3. Let's complete the statement as 5 groups of 3 circles."***
"Now I'm going to draw 5 groups of 3 circles."
Draw the groups of stars to match the statement either in equal groups or in an array.

Grade 1: ***"I'm going to count to see how many circles I have. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15. 5 groups of 3 circles is 15 circles."***

Grade 2 option A: ***"I'm going to skip count to see how many circles I have. 5, 10, 15. 5 groups of 3 circles is 15 circles."***

Grade 2 option B: ***"I know there are 15 circles because 5 groups of 3 is 15."***

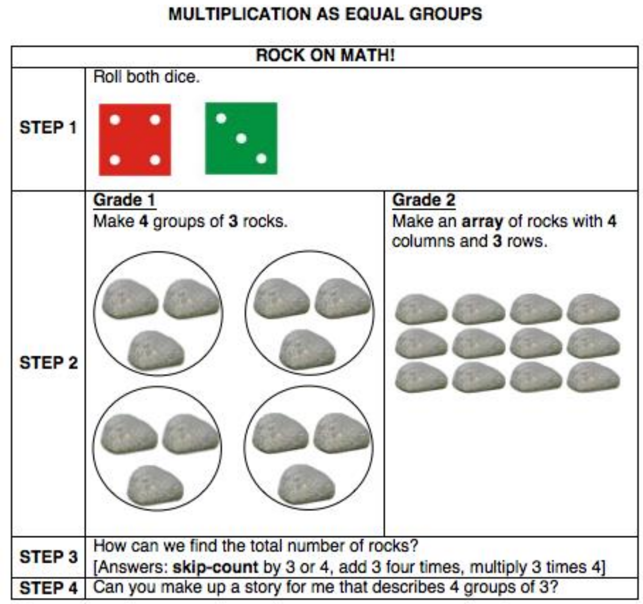
"You spin the spinner and I will write our statement."
Spin the spinner two times and write the statement [# groups of # circles].
"Draw [# groups of # circles]."
"How many circles are there?"

You may choose to use beans instead of drawing.

?
Extension Questions to ask:
"Can you write an expression to match our drawing?"
Grade 1 repeated addition (e.g., 5 groups of 3 is 3 + 3 + 3 + 3 + 3)
Grade 2 multiplication (e.g., 5 times 3 is 5 x 3)
"What is another strategy we could use to find the number of stars?"
"What's another way we could count to 15?"

!
Potential Corrective Feedback:
"Be careful, 5 groups of 3 means you need 5 groups. Draw 5 circles and put 3 stars in each circle."
"Let's try counting them again. I'll label each group as we skip count."

After:



MULTIPLICATION AS EQUAL GROUPS

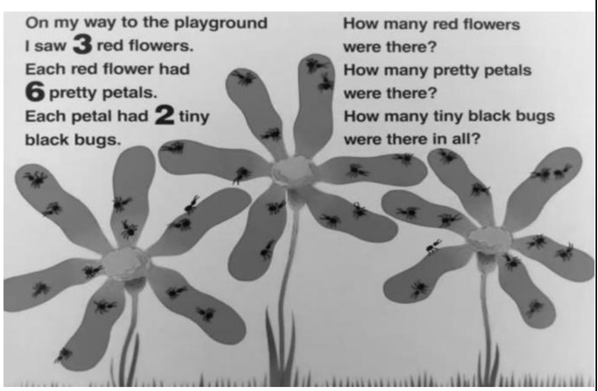
ROCK ON MATH!		
STEP 1	Roll both dice.	
STEP 2	**Grade 1** Make **4** groups of **3** rocks.	**Grade 2** Make an **array** of rocks with **4** columns and **3** rows.
STEP 3	How can we find the total number of rocks? [Answers: **skip-count** by 3 or 4, add 3 four times, multiply 3 times 4]	
STEP 4	Can you make up a story for me that describes 4 groups of 3?	

Figure 2. Mathematics game before (left) and after (right) receiving feedback from stakeholders through focus groups.

We solicited feedback on prototype storybook pages (Figure 3). The feedback was generally positive. Participants noted that the amount of text seemed appropriate for parents and children in the target population. However, they observed that the materials did not appear culturally relevant because they lacked a relevant storyline (or context) and relatable real-world situations. To remedy these problems, they suggested that the storybooks have characters and authentic storylines. In addition, they noted the importance of using culturally relevant words and avoiding language that was not common in Jamaica, such as "freeway" and "candy."

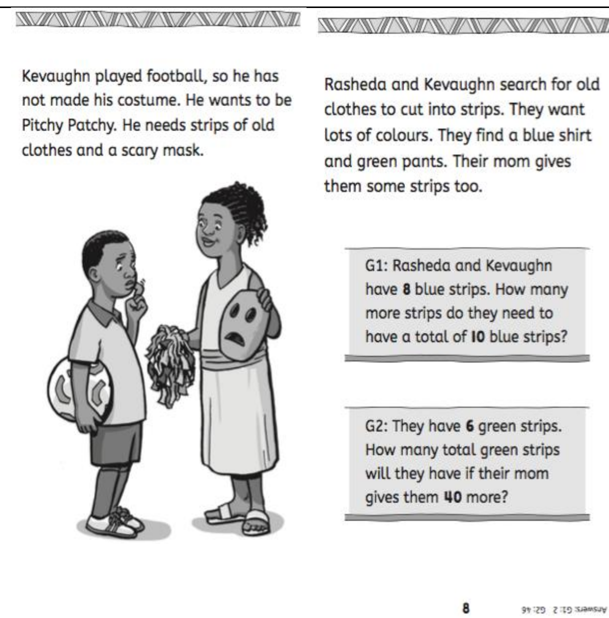
To respond to this feedback, an experienced author of short stories composed a storyline to be used across the intervention reflecting activities commonly experienced by children in Jamaica (e.g., going to the marketplace, playing football). Applying principles of UDL to ensure the storybooks were designed using evidence-based practices, each storybook was about 20 pages long with 10 illustrations, and the text was leveled to be appropriate for children in Grades 1 and 2. Though the text was leveled using US guidelines, the editors were experienced in developing books situated in international contexts. Sixteen mathematics questions, eight per grade level, were embedded into the storyline. Illustrations were created by an educational publishing group with previous experience developing storybooks for projects in international contexts. To maintain consistency, two main characters were used for all of the storybooks.

Before



Prototype storybook before focus groups

After



Revised storybook after focus groups

Figure 3. Storybook before (left) and (after) receiving feedback from stakeholders through focus groups.

Several other themes emerged from the focus groups, specifically concerning the usability, accessibility, and relevance of the learning materials for the target population. Notably, stakeholders suggested that the materials be scripted for each workshop to support future implementation of the home-based intervention and for potential scalability. Highly scripted training materials were proposed so that Jamaican educators could lead workshops and support parents' conceptual understanding of mathematics concepts while delivering workshops with fidelity. To address these concerns, the workshops were scripted in a way such that educators had time to model how parents could ask questions of their child, how to play the game and read the storybook, and how to dig deeper into the concepts.

Stakeholders shared concerns about the widespread fear of mathematics, noting a "cultural fear of mathematics." Efforts were made to reduce mathematics anxiety—for example, by including a jingle about mathematics and encouraging active parent engagement during the workshop. In addition, stakeholders alluded to the perception of differential ability in mathematics based on gender, suggesting that the materials be explicitly designed to dispel this misconception. To incorporate these suggestions, we focused on dispelling gender stereotypes and incorporating awareness of cultural conceptions of mathematics into the development of materials and during workshops. Consequently, the storylines of the books presented successful experiences with mathematics by girls and boys alike.

Overall, because prior research (Education Taskforce, 2004; Rattray & Lawson, 2011) has indicated that Jamaican parents do not perceive themselves as having the knowledge and skills required to support their children, feedback from the focus groups helped us to refine the prototypical materials for the home-based intervention that parents were familiar with and about which they had less anxiety – such as bingo and hopscotch.

External Review: Evaluating the Home-Based Intervention for Mathematical Accuracy and Cultural Relevancy

As shown in Figure 1, the next step in the refinement of our materials was to conduct a review of the home-based intervention from experts. Researchers and practitioners have undertaken external review processes in specific content areas to examine the appropriateness of curricular materials for their use and appropriateness (Bryant et al., 2008; Hughes & Dexter, n.d.; Simmons & Kame'enui, 2003). An external review process integrated seamlessly with the DBR framework because it provided an opportunity for the researchers to seek input from mathematics experts, practitioners, and key stakeholders such as the Ministry of Education, to ensure mathematical accuracy and cultural relevancy during the design and development process.

Evaluating Mathematical Accuracy

The home-based intervention as a whole was reviewed by an early childhood mathematics expert based in the U.S. but with extensive experience in international mathematics education. The expert reviewed the materials for (a) the extent to which the activity/game accurately targeted or represented the target mathematics content, (b) mathematical accuracy and clarity, (c) appropriateness of mathematical vocabulary, (c) appropriateness and accuracy of visual representations, (d) alignment of the activities/games to national content standards, (e) overall flow and pacing of the workshop, and (f) age/grade-level appropriateness of the activities/games. The materials were also reviewed by representatives of the Jamaican Ministry of Education, who provided additional feedback on usability, accessibility, and generally found the materials to be appropriate, fun, and engaging for parents. Among the revisions made to the home-based intervention at this phase were making sections of the workshop shorter, scripting sections more thoroughly to ensure fidelity to the mathematics pedagogy, and including more examples and modeling to provide additional clarity for parents.

Evaluating Cultural Relevance

Because the storybooks were rooted in the Jamaican culture and needed to be relevant to Jamaican families, we also conducted a systematic review of the storybooks for their cultural relevance. An expert in Jamaican cultural studies from a university in Jamaica reviewed the storybooks for (a) the proper use of Jamaican English (appropriateness of language and grammar practices customary in Jamaica), (b) the cultural relevance of the storylines (appropriateness of games, events, names), (c) the appropriateness of the images (whether the images seemed identifiable for local parents and children), and (d) the pertinence of the storylines to Jamaican life and culture. The expert noted that the books made use of proper Jamaican English, included culturally relevant storylines, incorporated appropriate images, and were pertinent. When necessary, the reviewer provided specific feedback and suggestions on aspects of language and culture. For example, a suggestion was made to use *maths* instead of *math*, depending on context. As another example, the word *"candies,"* which is not used by locals, was changed to *"sweeties."* One storybook referenced an outdated theme from Jamaican culture, which was then updated to reflect more relevant and appropriate contextual relevance. While offering clarifications and minor revisions, the Ministry representatives information. Other language-based recommendations were incorporated into the final versions of the storybooks.

Overall, the external review process that encompassed mathematical accuracy and cultural relevance provided an opportunity for us to identify and adjust issues based on reviewer feedback during the development process to ensure ease and relevance of implementation.

Feasibility Study: Evaluating the Feasibility of the Home-based Intervention Prior to Implementation

After revisions were made to the mathematics learning materials and educator-led parent workshops based on the focus groups and the external review, we conducted a small-scale feasibility study using materials from one workshop to answer the question of "Can it work?" (Orsmond & Cohn, 2015). The feasibility study with Jamaican parents tested whether an educator could be trained to implement the educator-led workshop, whether the pacing of the workshop was appropriate, and whether the end-users (the parents) could grasp the concepts as presented in the workshop. In addition, the feasibility study invited the participation and feedback of stakeholders in a naturalistic setting, and considered the cultural relevance of parents, aligning with our DBR framework (Wang & Hannafin, 2005).

A Jamaican educator was selected by the Ministry to support the feasibility study. The educator received one day of training on how to implement the mathematics learning materials with parents in a workshop format. The following day, the educator conducted the workshop at a convenient location for participating parents or caregivers. Seven parents or caregivers of children in Grades 1 and 2 were selected by the Ministry of Education to participate in this feasibility study. All seven resided in a rural community and received federal assistance. All were women. The workshop lasted for approximately 3 hours. Parents were asked to try the mathematics learning materials with their children before a scheduled follow-up session. At the follow-up session, parents described their experiences as they played the games and read the storybook with their children. Field notes and audio or video recordings were obtained and subsequently analyzed for themes, similar to the focus groups.

Several themes emerged from the feasibility study. The first was that the project design with educator-led parent workshops was feasible for both the educator and the parents. The educator was able to use the script created to deliver the workshop materials to parents as intended. She was able to play the games after having them modeled and playing with us. She was also able to keep the parents interested and engaged. The scripted workshop materials ensured delivery with a reasonably high degree of fidelity after the educator had been trained by our research team. Fidelity was informally measured as the alignment between the script and the educator's actions with parents. The educator maintained the integrity of the script and only made minor changes to provide additional explanations when needed.

A second theme from the feasibility study was that both the educator and parents were able to use the mathematics learning materials. The educator was able to use the manipulatives effectively, and parents were able to engage with the materials. Of the three parents who came to the follow-up session, all were able to play the game successfully with their children. One of the returning parents read the storybook with her children without any challenges. The other two parents did not read the storybook owing to time constraints. It was unknown as to why the other four parents did not return for the follow-up session.

Another tentative finding was that the mathematics learning materials offered the appropriate level of challenge, fun, and engagement for parents and children. During the workshop, parents appeared to have fun engaging with the materials and working with the educator. During the follow-up session, parents reported having enjoyed learning the material during the workshop and liked working together with other parents. Parents also reported that the game was fun to play with their children. All agreed that the games and questions in the storybook were appropriately challenging for their children.

Finally, we observed that the content of the workshops needed to be streamlined to reduce the time requirement. During the training session with the educator, the script was modified to improve clarity and engage parents more actively. Even so, to deliver the workshop as scripted, the educator spent approximately 3 hours with the parents. The amount of content was reduced for future workshops so as to keep parents more engaged over a shorter duration of time (about 2 hours). Overall, the feasibility study allowed us to identify issues in the feasibility of implementation and adjust the educator-led workshop and mathematics learning materials accordingly.

Discussion

This paper provided an example of a home-based intervention to support parent-involvement in mathematics with a focus on parents of primary-school children, an area where research has been limited (Anders et al., 2012; Blevins-Knabe & Musun-Miller, 1996; DeFlorio & Beliakoff, 2015; Fan & Chen, 2001; Jordan et al., 2006; LeFevre et al., 2009). The purpose of this paper was to describe the iterative development using DBR of a home-based intervention to support parents' involvement with their children in mathematics in Jamaica. The home-based intervention included mathematics learning materials covering foundational early mathematics concepts and educator-led workshops to support parents' understanding of the concepts and use of the materials. We described the iterative phases of DBR to incorporate end-users' feedback throughout the development process. Research activities described include focus groups, an external review, and a feasibility study.

Care was taken to design mathematics learning materials that address multiple prongs of numeracy and incorporate accessibility features, such as UDL and visual representations, and are culturally relevant. In addition, the materials incorporated evidence-based practices, such as explicit and systematic instruction, use of visual representations, game-based learning, and storybooks, to maximize parent-child interactions (Purpura et al., 2017; Ramani & Siegler, 2008). Accessibility was attended to by incorporating the principles of universal design and culturally relevant materials and activities. The feasibility study showed that parents found the materials usable, accessible, and culturally relevant.

A major factor that shapes the level of parent-child interactions is *how* the learning materials are introduced to parents. The educator-led workshops with parents were highly scripted for purposes of scalability and to permit the materials to be implemented as designed. It is critical to prepare parents to help their child achieve conceptual understanding of the topic before transitioning to the game-based learning and the storybook. Keys to effective preparation are appropriateness in pacing, accuracy in content, integration of cultural relevance and engagement, and reduction of anxiety throughout the process.

Implications for Future Implementation of the Home-based Intervention

The iterative development of the mathematics learning materials for parents and their children and the educator-led workshops was necessary for the intervention to be culturally and age/grade-level relevant, feasible for families, and usable by families with differing educational backgrounds and reading levels. Through the iterative process, it became increasingly clear that cultural relevance was important for parents' engagement in the materials, particularly because many of them do not see themselves as mathematicians or fluent in mathematics, and because the researchers developing the materials did not have a background in the Jamaican culture. Furthermore, the scripting of the educator-led workshops provided the necessary specifications for the workshops to be scaled in a systematic way even though the educators may have various backgrounds.

The DBR framework that guided each phase in the development cycle shown in Figure 1 provided distinct pieces of feedback from stakeholders and reviewers to ensure that the home-based intervention was maximally usable, accessible, and culturally relevant. The focus groups helped set the stage for designing materials that were culturally relevant by providing insights into the Jamaican culture such as mathematics anxiety, gender stereotypes, and so on. The focus groups were also helpful in providing some initial feedback into the usability and accessibility of the prototypical materials from the stakeholders' perspectives. The focus groups served as an important phase in our project and underscored the importance of involving those who would be using the materials early in the development process (Anderson & Shattuck, 2012).

Next, after the learning materials were developed based on the feedback we received from the focus groups, we scripted an educator-led workshop. We conducted an external review to examine the materials for mathematical accuracy and cultural relevancy. The purpose of this review was to determine if we reached our goal of designing maximally usable, accessible, and culturally relevant materials based on the feedback we received during the focus groups. Experts reviewed the mathematical accuracy of the materials and general relevance of the content. However, a separate review was conducted to examine the cultural appropriateness of the storybooks to the Jamaican culture. Because the focus groups highlighted a sense of mathematics anxiety and some issues with gender stereotypes, we wanted to make sure that the storybooks were relatable and brought in familiar parts of the Jamaican culture, while dispelling a sense of gender roles related to mathematics. The feedback we received from the external reviewers helped to make the final materials more meaningful and relevant.

Finally, the feasibility study with Jamaican parents tested whether an educator could be trained to implement the workshop, whether the pacing was appropriate, and whether parents could grasp the concepts as presented in the workshop. With some fine-tuning of the materials, we concluded that we met our goals: The educator could successfully lead the workshops, the pacing was appropriate, and parents could grasp the content. We also found that parents liked working with the materials, which gave us some confidence about the appropriateness, relevance, and level of engagement created by the materials.

We hypothesize that the use of the research-based, rigorously designed, and culturally relevant mathematics learning materials described in this paper will increase the quality and quantity of parents' interactions with their children, thus serving to raise children's performance in mathematics. It should be noted, however, that the outcomes of parents' involvement and engagement have not been analyzed in this paper. We expect that the effectiveness of home-based interventions described here could impact parent involvement and engagement. The iterative design used to gather and assimilate feedback about the accuracy and cultural relevance of the home-based intervention may help support the future development and design of learning materials across cultures and contexts in which resources are limited and parents may need support to design and implement mathematics learning opportunities at home.

Notes

1. Specific to this paper, parental involvement refers to ways in which mathematics learning can be facilitated at home — for example, by providing parents with information, materials, strategies, and ideas about how to support their children's learning of content taught in school (Sheldon & Epstein, 2005).
2. Collaborating with the community and learning at home may both be examples of parental involvement (Epstein, 1994), the former involves parents working *indirectly* to support their children by participating with the community to strengthen school programs and family practices, while the latter involves parents working with their children *directly*.

Author's Note

This work was supported by the Inter-American Development Bank and conducted in collaboration with the Jamaican Ministry of Education. The opinions and conclusions advanced herein do not necessarily reflect those of the Inter-American Development Bank, the Ministry of Education, or their staff. This work could not have been completed without the support of Erica Simon and many other stakeholders who assisted in research activities.

References

Adelson, J. L., Dickinson, E. R., & Cunningham, B. C. (2015). Differences in the reading-mathematics relationship: A multi-grade, multi-year statewide examination. *Learning and Individual Differences, 43,* 118-123.

Anders, Y., Rossbach, H-G., Weinert, S., Ebert, S., Kuger, S., Lehrl, S., & von Maurice, J. (2012). Home and preschool learning environments and their relations to the development of early numeracy skills. *Early Childhood Research Quarterly, 27*, 231- 244.

Anderson, R. C. (1994). Role of reader's schemata in comprehension, learning, and memory. In R. B. Ruddell, M. R. Ruddell & H. Singer (Eds.), *Theoretical models and processes of reading* (pp. 469-482). Newark, DE: International Reading Association.

Anderson, T., & Shattuck, J. (2012). Design-based research: A decade of progress in education research? *Educational Researcher, 41*(1), 16-25.

Bernal, G., & Saenz-Santiago, E. (2006). Culturally centered psychosocial interventions. *Journal of Community Psychology*, *34*, 121–132.

Blevins-Knabe, B., & Musun-Miller, L. (1996). Number use at home by children and their parents and its relationship to early mathematical performance. *Early Development and Parenting, 5*(1), 35-45.

Bryant, B. R., Bryant, D. P., Kethley, C., Kim, S. A., Pool, C., & Seo, Y. (2008). Preventing mathematics difficulties in the primary grades: The critical features of instruction as part of the equation. *Learning Disability Quarterly, 31*, 21-35.

CAST (2011). *Universal Design for Learning Guidelines Version 2.0*. Wakefield, MA: Author.

Carrell, P. (1987). Content and formal schemata in ESL reading. *TESOL Quarterly, 21*(3), 461-481.

Center for Universal Design (1997). *The Principles of Universal Design (Version 2.0).* Raleigh, NC: North Carolina State University.

Cardona, J. R., Domenech-Rodriguez, M., Forgatch, M., Sullivan, C., Bybee, D., Holtrop, K., Escobar-Chew, A., Tams, L., Dates, B., & Bernal, G. (2012). Culturally adapting an evidence-based parenting intervention for Latino immigrants: The need to integrate fidelity and cultural relevance. *Family Processes, 5,* 56-72.

Cobb, P., diSessa, A., Lehrer, R., Schauble, L. (2003). Design experiments in educational research. *Educational Researcher, 32*(1), 9-13.

Cotton, K., & Wikelund, K. (2005). Parent involvement in education. Available at: http:/www.nwrel.org/.

DeFlorio, L., & Beliakoff, A. (2015). Socioeconomic status and preschoolers' mathematical knowledge: The contribution of home activities and parent beliefs. *Early Education and Development, 26,* 319-341.

de Jong, T., Ainsworth, S., Dobson, M., van der Hulst, A., Levonen, J., Reimann, P. et al. (1998). *Acquiring knowledge in science* *and math: The use of multiple representations in technology-based learning environments*. In M. W. van Someren, P. Reimann, H. P. Roshulzen, & de Jong, T. (Eds.) Learning with multiple representations (pp. 9-40). Amsterdam: Pergamon.

Design-Based Research Collective. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher, 32*(1), 5-8.

Education Taskforce. (2004). *Taskforce report on education reform Jamaica* (rev. ed.). Kingston, Jamaica: Information Service.

Epstein, J. (1994). *Theory to practice: School and family partnerships lead to school improvement and student success*. In C. L. Fagnano & B. Z. Werber (Eds.) School, family, and community interaction: A view from the firing lines (pp. 53-71). Boulder, CO: Westview.

Fan, X., & Chen, M. (2001). Parental involvement and students' academic achievement: A meta-analysis. *Educational Psychology Review, 13*(1), 1-22.

Flores, A. (2002*). Geometric representations in the transition from arithmetic to algebra*. In F. Hitt (Ed.), *Representations and mathematics visualization* (pp. 9-29). México: Departamento de Matemática Educativa del CINVESTAV-IPN.

Gersten, R., Chard, D. J., Jaynathi, M., Baker, S. K., Morphy, P., & Flojo, J. (2009). Mathematics instruction for students with learning disabilities: A meta-analysis of instructional components. *Review of Educational Research, 79*, 1202-1242.

Gertler, P., Heckman, J., Pinto, R., Zanolini, A., Vermeerch, C., Walker, S., … & Grantham-McGregor, S. (2014). *Labor market returns to an early childhood stimulation intervention in Jamaica: A 20-year follow-up to an experimental intervention in Jamaica*. (report no. w19185). National Bureau of Economic Research, Cambridge, MA.

Hallet, D., Nunes, T., & Bryant, P. (2010). Individual differences in conceptual and procedural knowledge when learning fractions. *Journal of Educational Psychology, 102,* 395-406.

Hart, S. A., Ganley, C. M., & Purpura, D. J. (2016). Understanding the home math environment and its role in predicting parent report of children's math skills. *PLoS ONE, 11*(12): e0168227.

Heinze, A., Star, J. R., & Verschaffel, L. (2009). Flexible and adaptive use of strategies and representations in mathematics education. *The International Journal on Mathematics Education, 41,* 535-540.

Hickman, P., Pollard-Durodola, S., & Vaughn, S. (2004). Storybook reading: Improving vocabulary and comprehension for English-language learners. *International Reading Association,* 720-730.

Hill, N. E., & Tyson, D. F. (2009). Parental involvement in middle school: A meta-analytic assessment of the strategies that promote achievement. *Developmental Psychology, 45*(3), 740-763.

Hughes, C., & Dexter, D. D. (n.d.). Selecting a scientifically-based core curriculum for tier 1. Retrieved on 11/24/14 from http://rtinetwork.org/learn/research/selectingcorecurriculum-tier1

Jordan, N. C., Kaplan, D., Nabors-Oláh, L, & Locuniak, M. N. (2006). Number sense growth in kindergarten: A longitudinal investigation of children at risk for mathematics difficulties. *Child Development, 77*, 153-175.

Kilpatrick, J., Swafford, J., & Findell, B. (Eds.) (2001). *Adding it up: Helping children* *learn mathematics*. Washington, DC: National Academy Press.

Krueger, R. A. (2009). *Focus groups: A practical guide for applied research* (4th ed.) Thousand Oaks, CA: Sage.

Ladson-Billings, G. (1994). *The Dreamkeepers: Successful teaching for African-American students*. San Francisco, CA: Jossey-Bass.

LeFevre, J., Skwarchuck, S., Smith-Chant, B. L., Fast, L., Kamawar, D., & Bisanz, J. (2009). Home numeracy experiences and children's mathematics performance in the early school years. *Canadian Journal of Behavioral Science, 41*(2), 55-66.

Lopez, C. O., & Donovan, L. (2009). Involving Latino parents with mathematics through family math nights: A review of the literature. *Journal of Latinos and Education, 8,* 219-230.

Miedel, W. T., & Reynolds, A. J. (1999). Parental involvement in early intervention for disadvantaged children: Does it matter? *Journal of School Psychology, 37*, 379-402.

Ministry of Education (Jamaica) (2011). *The National Comprehensive Numeracy Programme*. Kingston, Jamaica.

Mitchell, R., Charalambous, C. Y., & Hill, H. C. (2014). Examining the task and knowledge demands needed to teach with representations. *Journal of Mathematics Teacher Education, 17*, 37-60.

Munroe, G. (2009). *Parental involvement in education in Jamaica: Exploring the factors that influence the decision of parents to become involved in the education of their children*. (Doctoral dissertation, University of Toronto). Available from ProQuest Dissertations & Theses database.

Musun-Miller, L., & Blevins-Knabe, B. (1998). Adults' beliefs about children's mathematics: How important is it and how do children learn about it? *Early Development and Parenting, 7*, 191-202.

Olatoye, R. A. & Agbatogun, A. O. (2009). Parental involvement as a correlate of pupils' achievement in mathematics and science in Ogun State, Nigeria. *Educational Research and Review, 4*, 457-464.

Orsmond, G. I., & Cohn, E. S. (2015). The distinctive features of a feasibility study: Objectives and guiding questions. *OJTR: Occupation, Participation, and Health*. 35(3), 169-177.

Park, B., Chae, J-L., Boyd, B. F. (2008). Young children's block play and mathematical learning. *Journal of Research in Childhood Education, 23*(2), 157-162.

Powell, C. (1999). Overview of early child-care and education programmes and Jamaican case studies. *Food and Nutrition, 20,* 108-120.

Purpura, D. J., Hume, L. E., Sims, D. M., & Lonigan, C. J. (2011). Early literacy and early numeracy: The value of including early literacy skills in the prediction of numeracy development. *Journal of Experimental Child Psychology, 1110,* 647-658.

Purpura, D. J., & Napoli, A. R. (2015). Early numeracy and literacy: Untangling the relation between specific components. *Mathematical Thinking and Learning, 17,* 197-218.

Purpura, D. J., Napoli, A. R., Wehrspann, E. A., & Gold, Z. S. (2017). Causal connections between mathematical language and mathematical knowledge: A dialogic reading intervention. *Journal of Research on Educational Effectiveness, 10*(1), 116-137.

Ramani, G. B., & Siegler, R. S. (2008). Promoting broad and stable improvements in low-income children's numerical knowledge through playing number board games. *Child Development, 79,* 376-394.

Rattray, R., & Lawson, D. S. (2011). Schools seek strategies for better 'parental student support'. Retrieved 11/19/14 from www.jnbs.com/schools-seek-strategies-for-better-'parental-student-support'.

Rittle-Johnson, B., & Alibali, M. W. (1999). Conceptual and procedural knowledge of mathematics: Does one lead to the other? *Journal of Educational Psychology, 91,* 175-189.

Rose, D. (2000). Universal design for learning. *Journal of Special Education Technology, 15*(1), 67-70.

Shanahan, T., & Shanahan, C. (2008). Teaching disciplinary literacy to adolescents: Rethinking content-area literacy. *Harvard Education Review, 78*(1), 40-59.

Sheldon, S. B., & Epstein, J. L. (2005). Involvement counts: Family and community partnerships and mathematics achievement. *Journal of Educational Research, 98*(4), 196-207.

Silinskas, G., Leppänen, U., Aunola, K., Parrila, R., & Nurmi, J-E. (2010). Predictors of mothers' and fathers' teaching of reading and mathematics during kindergarten and Grade 1. *Learning and Instruction, 20,* 61-71.

Simmons, D. C., & Kame'enui, E. J. (2003). *A consumer's guide to evaluating a core reading program for grades K-3: A critical elements analysis.* University of Oregon: Institute for the Development of Educational Achievement (IDEA). Retrieved November 1, 2014 from http://reading.uoregon.edu/curricula/index.ghp.

Thompson, K. M., Gillis, T. J., Fairman, J., & Mason, C. A. (2014). *Effective strategies for engaging parents in students' learning to support achievement.* Orono, ME: Maine Education Policy Research Institute, University of Maine.

Wang, F., & Hannafin, M. J. (2005). Design-based research and technology-enhanced learning environments. *Educational Technology Research and Development, 53*(4), 5-23.

Whyte, J. C., & Bull, R. (2008). Number games, magnitude representation, and basic number skills in preschoolers. *Developmental Psychology, 44*(2), 588-596.

Young-Loveridge, J. M. (2004). Effects on early numeracy of a program using number books and games. *Early Childhood Research Quarterly, 19*, 82-98.

About the Author(s)

Dr. Pooja Shivraj is a Psychometrician and Researcher at the American Board of Obstetrics and Gynecology. Her work emphasizes the use of measurement and statistics to enhance the reliability and validity of exam scores in credentialing. She also designs and leads research projects related to assessments and their intended use.

Dr. Leanne Ketterlin Geller is the Texas Instruments Endowed Chair in Education and professor in the Simmons School of Education and Human Development at Southern Methodist University. Her research focuses on supporting student achievement in mathematics through developing technically rigorous formative assessment procedures and effective classroom practices. Her work emphasizes valid decision-making systems for students with diverse needs.

Dr. Deni Basaraba is the data analyst for the Bethel School District in Eugene, OR whose primary responsibilities include analysis of

student performance data, survey and observation development, securing external funding, and dissemination. She also holds research affiliate positions with the Research in Mathematics Education unit at Southern Methodist University and the University of Oregon through which she collaboratively explores issues related to bilingual education programs and second language acquisition, the role of language in mathematics, and the technical adequacy of published and teacher-developed assessments.

Josh Geller holds a Master's degree in Special Education, and has served as a research specialist for state- and federally-funded research projects since 2001. His work focuses on designing mathematics assessments to support all students, primarily through writing accessible items. Most of his work centers on early grades mathematics. He supports multiple phases of project implementation and coordination, paying particular attention to incorporating the needs of different stakeholders.

Cassandra Hatfield is a Research Project Manager at Southern Methodist University's Research in Mathematics Education. She has previous experiences as a middle school math teacher and elementary mathematics coach and specialist. Cassandra's research interests include the impact that systematic teacher training and coaching has on student achievement.

Dr. Emma Näslund-Hadley is a lead education specialist at the Inter-American Development Bank (IDB) where she coordinates the Bank's efforts to improve STEM education in Latin America and the Caribbean. Her research looks at what happens inside mathematics and science classrooms, exploring what works to improve teacher skills and student learning. She has a master's degree in international economics and finance from the University of Linkoping and a master's degree in public affairs from Princeton University.