Designing for Diversity: Strategies for Embedding Mathematics in Out-of-school Programs for Children in the Elementary Grades

Marlene Kliman, Nuria Jaumot-Pascual, and Valerie Martin

Abstract

Informal (out-of-school) education, with emphasis on local community and resources, can be particularly beneficial to children from non-dominant cultures. To support integration of more mathematics into such programs, we worked with informal educators based in public libraries (including librarians and after-school educators) to create and make available English and Spanish mathematics activities that they could embed in their daily work with children. We discuss self-reported impacts on informal educators' math-related attitudes, beliefs, and professional practices.

Discussion And Reflection Enhancement (DARE) Pre-Reading Questions

1. Do you think that mathematics is culture-bound and contextual? Why or why not?
2. Are there circumstances in which it seems appropriate to view mathematics as devoid of context and culture? Explain.
3. What do you think is an appropriate role for mathematics in out-of-school programs such as after-school and library programs?

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Imagine the chart in Figure 1 is posted near the checkout desk of a public library branch in a large city. A group of children ages 8-11, having put their own information on the chart, eagerly watches the data set evolve as passers-by contribute. They silently root for even more stickers in the columns for the #5 and #23 buses, which are slated for elimination. The city Transportation Department has proposed cutting these bus routes in order to close a budget shortfall; the potential cuts have particular impact on low-income neighborhoods—including the area in which the library branch is located. Like many in the neighborhood, the children and their families rely heavily on the 5 and 23 buses for transportation to jobs, to shops, and to the library, which lies right along the bus routes.

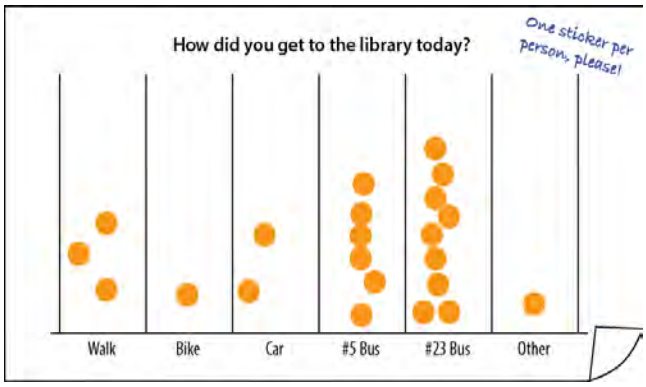

Figure 1. Collecting data on an issue of community concern.

Lupe, the children's after-school group leader, encourages them to think of how they can demonstrate to the Transportation Department the extent to which cutting service will impact their community. The group decides to gather data to see how many library patrons arrive by bus. While not a foolproof method of proving the value of the bus service (e.g., some people might be able to walk or drive if bus service were cut), it is an approach that yields a benchmark.

As the dots on the chart accumulate, children reflect on the growing patterns of responses: Marcel notes that the majority of respondents arrived by bus; Sofia observes that the number who took the 23 bus alone is greater than the number of non-bus arrivals; Ximena, reflecting on prior group conversations about characteristics of different neighborhoods in the city, wonders whether there would be so many bus users if they collected data at a library branch in Rosedale, a wealthy neighborhood across town. Lupe guides the group to consider what constitutes a sufficient sample for presentation to the Transportation Department. They decide to gather data for a week, requesting only one response per person.

At the end of the week, the group has 201 responses, with 158 indicating arrival by the #5 or #23 bus. They make a plan to write to the Transportation Department to ask them to reconsider their plan to cut the bus routes because, according to their data, the large majority of library patrons—158 out of 201, or 79%—arrive by bus that week. In their letter, they will underscore the fact that without a way to get to the library, many residents no longer have access to free computers, ELL classes, and after-school programs. These children are learning to use math as a way to explore and potentially make a case for addressing what they see as an injustice.

Each week, as Lupe plans programs for and with the children, she finds ways to engage them in collecting and analyzing data to enhance the topic: sometimes data serves as a way to spark discussion of a social issue; sometimes as a springboard for investigating commonalities and differences among the group; and sometimes, as in this instance, as a basis for taking action.

Role of Mathematics in an Out-of-school Program

Although topics that form the core of out-of-school programming for the elementary grades are replete with mathematics opportunities, scenes such as the above—in which children use mathematics in a way that resonates with their interests—are rare. One obstacle to integration

of mathematics in such programs is that many adults lack mathematical comfort and confidence. Informal educators, from after-school providers to librarians to parents, care deeply about children's mathematical success, but they often are math-avoidant themselves and thus shy away from mathematics with children (Gasbarra & Johnson, 2008; Intel, 2009). Another obstacle is a widespread conception of mathematics as devoid of context. In everyday life, adults estimate, measure, and navigate, but they do not typically think of these as mathematics and do not share strategies with children (Esmonde, 2013; Kliman, 2006; Lange & Meaney, 2011). Rather, they are likely to view mathematics as a set of culturally neutral facts and algorithms (Allexsaht-Snider, 2006; Martin, 2009a, 2009b).

When informal educators do integrate mathematics into their programs, children stand to benefit in several ways. For all children, participating in out-of-school activities that embed mathematics—from tithing to card playing to shopping—bolsters skill development, appreciation of the relevance of mathematics, and mathematics attitudes (Guberman, 2004; Harris, 2011; Nasir, Hand, & Taylor, 2008). Combining mathematics and social justice in an after-school mathematics project can also lead to children to develop mathematical understandings needed to explore and address injustices (Turner, Varley Gutiérrez, & Díez-Palomar, 2011; Turner, Varley Gutiérrez, Simic-Muller, & Díez-Palomar, 2009; Simic-Muller, Turner & Varley, 2009).

For children least likely to succeed during the school day, including children from non-dominant cultures and children from low-income families, out-of-school programs confer particular benefits, in part because discontinuities between home/community and school cultures are substantially mitigated (Noam, Biancarosa, & Dechausay, 2003). For instance, unlike in public school, where 83% of teachers are White (Cowan, 2010), after-school staff members usually reflect the diversity of the enrolled children, and many have strong local community ties. The emphasis on local resources and community-based activities prevalent in elementary-grades out-of-school programs can promote belonging and self-esteem, which are important ingredients in learning (Miller, 2003).

Although informal educators rarely embed mathematics in their offerings, they *could*: they typically have substantial autonomy in programming, unlike school teachers, who may be limited in efforts to integrate children's everyday experiences in mathematics class because of required testing and curriculum (McCulloch & Marshall, 2012; Wager, 2012). To engage children, particularly those who flourish in out-of-school settings but struggle in school, a critical first step is to engage informal educators (especially those who may be math avoidant themselves). This paper describes impacts of a project intended to spark a new mathematical reality for out-of-school programs and the informal educators who lead them.

MATH OFF THE SHELF Project Background

TERC (originally known as Technical Education Research Centers) initiated MATH OFF THE SHELF (MOTS) to investigate strategies for bolstering the presence of mathematics in a wide range of library-based programs for elementary-grade children. Public libraries exist in virtually every community in the nation, and increasingly, families rely on them as a free, safe place for children to spend time in the absence of other out-of-school care. Library-Based Informal Educators (LBIEs) —including after-school providers, children's librarians, and youth workers— offer programs such as story and craft times, summer reading events, and drop-in after-school activities.

Design Phase

This two-year phase began by collaborating with LBIEs to create interdisciplinary English and Spanish mathematics activities that they could embed in the projects, activities, and conversations that form the core of their daily work with children. We employed an iterative design process in conjunction with several dozen LBIEs in four regions: Queens, NY, Westchester County, NY, and several communities in MA and CT. The majority of our LBIE partners were based in urban areas with significant low-income Latino/a or African-American population. First, we solicited from LBIEs upcoming programming themes (e.g., poetry month), special events (e.g., El día de los niños/El día de los libros), and needs (e.g., games children can play quietly while waiting around, activities in

English and Spanish that allow family members of all ages to participate together). For instance, two of the many family activities created include "Say It with Shapes / Jugando con Geometría" described below, and an activity involving creating towers from recycled materials.

After about 75 initial LBIE partners chose among, implemented, and gave feedback on the activities, we revised and then invited a wider group to try them. During this period, we gathered feedback via dozens of observations, primarily at local sites, and hundreds of phone conversations with LBIEs at distant sites. We abandoned or conducted substantial revisions to activities that the majority of LBIEs reported were not engaging to children, or which LBIEs chose not to implement. If most LBIEs described leading an activity in a didactic manner or noted that children seemed to be doing little or no mathematics during the activity, we typically revised to incorporate questions and prompts LBIEs could use to draw out the mathematics as they interacted with children.

Our process continued until we had a varied bank of vetted activities, including dozens each of projects, games, and short activities (http://mixinginmath.terc.edu) that connected with NCTM Standards for the elementary grades (NCTM, 2000). The activities were developed prior to but address many key K-5 topics in the *Common Core State Standards for Mathematics* (NGA, 2010). Some examples follow:

Using Mathematics to Spark Exploration of a Community Issue

The data collection activity described above is based on "Quick Questions" (see Appendix), in which children collect data, explore range, mode, and overall data shape, and gather and analyze samples from different populations. LBIEs and children have used this activity to investigate a variety of topics, such as local demographics (e.g., language(s) library patrons speak at home, country of birth).

Using Mathematics for Self-expression

Crafts, projects, and development of personal voice are integral to many library-based out-of-school programs for the elementary grades. "Say It with Shapes" offers an opportunity for self-expression with patterns and words. Children select from among a set of shapes, each imprinted with an English or Spanish word, to create a poem such that each line follows a visual pattern. Children may use any pattern, as long as they can describe it, whether with words ("triángulo, triángulo, cuadrado"), letters ("AAB"), or in some other way. The activity includes blanks, so that children or LBIEs can contribute words in any language.

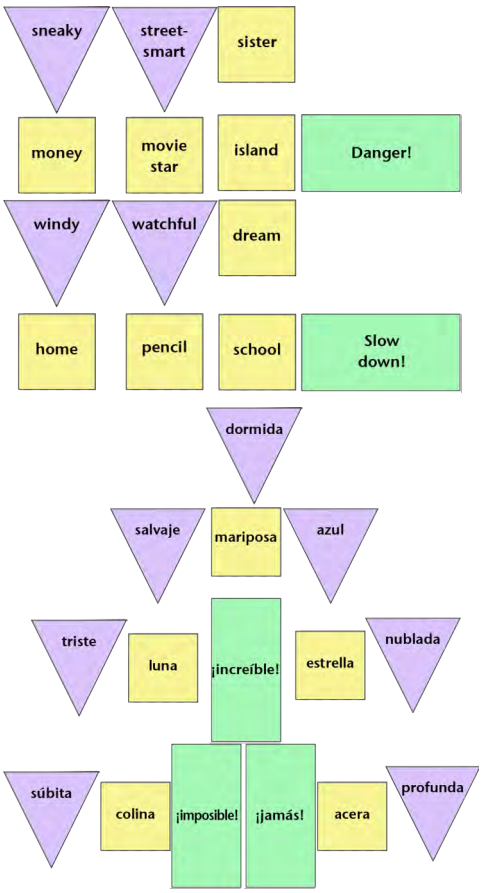

Figure 2. Creating poetry with patterns.

Using Mathematics to Engage Children in Assuming Responsibility in Daily Activities

At some library-based programs, children help prepare daily snack; with "Double or More," children also do mathematics. They start with a recipe for one or just a couple of people, and they work together to adjust the recipe for the group. Younger children might determine the increased quantities by repeated measurement, older ones by repeated addition or by multiplication. Even

those who measure with handfuls and pinches, common across many cultures, need to attend to keeping amounts in proportion as they adjust the recipe. Unlike with textbook word problems about cooking, with "Double or More" children choose the recipe or bring it from home, decide how much to increment it, and then go on to make and eat the food.

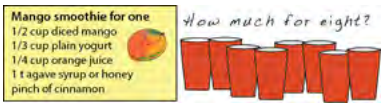

Figure 3. Staying in proportion.

Extend-and-evaluate Phase

At the start of this three-year phase, some selected activities from MoTS were made available on a public website (http://mixinginmath.terc.edu). For evaluation purposes, we promoted the activities to groups of LBIEs in San Jose (CA), St. Louis (MO), selected low-income communities in Arizona and Florida, and additional sites in the original four regions. At each site, we connected with a library leader or library-based after-school leader, who in turn, encouraged LBIEs to review our website and use any of activities they wished, and to provide us with information on what they used and how. We used their input as a basis for final revisions and for development of activities to meet additional LBIE needs.

During this phase, our independent evaluator, Char Associates, surveyed LBIEs on impact of exposure to MoTS activities on a variety of math-related topics, including their attitudes and beliefs, incorporation of mathematics into their work with children, and reasons for using mathematics. Baseline data was gathered on a subset of these issues at the beginning of the project by the independent evaluator. Data reported in this paper are drawn from evaluator reports (Char & Foote, 2009; Char & Berube, 2010; Char & Clark, 2011) and are hereafter referred to only by year.

Evaluation of the Project

For each of three years, LBIEs exposed to MoTS activities in the aforementioned regions were invited via e-mail to click on a link to a survey containing about 40 multiple choice and open-response items. (We use "exposed" to mean learned of the MoTS activities and website at least four months earlier.) Participants received the survey link from the evaluators or from their supervisors, but raw survey data was accessible only to evaluators. Each year, the response rate was approximately 50%. Within each year, each LBIE generally came from a different library. From year to year, the LBIEs included some different people (due to turnover of LBIEs) but from the same regions.

Table 1
Number of LBIEs Surveyed

Survey year	2008 (baseline)	2009	2010	2011
Number of LBIEs	67	28	83	148

Each year, LBIE respondents reflected a range of involvement (e.g., from participant in the design phase to awareness of the project through a regional e-mail), number of months/years since initial exposure to MoTS activities, professional role, and use of MoTS (from those who chose to use it daily to those who reported never using it). In this paper, we provide data in aggregate for each year, as disaggregation and tracking individuals over time was beyond budgetary constraints. Survey questions varied to some extent from year to year.

Change in Frequency of Mathematics Activities Offered in Library Settings

The LBIEs that participated in the project offered activities such as story times, library orientations, craft projects, and activities children can do independently. At baseline, approximately 10% of LBIEs surveyed ever used mathematics in *any* of these contexts (2009). Because of exposure to MoTS activities, the majority reported providing a variety of math-related offerings at least monthly (see Table 2).

Many LBIEs included mathematics weekly or even daily: 28% reported including mathematics in craft activities with children weekly, and 3% daily; 20% of those surveyed now led math-related activities for families at least

Table 2

Changes in Incorporation of Mathematics into Offerings

Year	Percent of LBIEs from that year (see Table 1)	"Because of exposure to MOTS, I now *at least monthly*..."
2009	74%	... combine mathematics and craft activities
2009	53%	... incorporate mathematics in story times (e.g., with choice of books, conversations about books, questions I ask when reading to children etc.)
2009	26%	... fold mathematics into library orientations
2010	53%	... create my own mathematics-related activities (apart from using MOTS activities)
2010	53%	... offer mathematics-related independent activities

monthly, compared to 2% baseline (2010).

In explaining how they implemented their more frequent math offerings, LBIEs emphasized that participation in the project enabled them to find ways to integrate mathematics into what they are already doing. For instance, one LBIE who regularly led story times noted that now, "I'm more apt to bring in a ruler or different sized objects to illustrate part of a story" (2010). As a result of MOTS activities, this LBIE incorporated a mathematical lens into story times, drawing out sizes and measurements in the stories.

Change in Communication about Mathematics

In addition to *doing* more mathematics with children, LBIEs reported *talking about* mathematics a great deal more: 61% noted that because of MOTS, the nature of their communication with children changed; 54% noted changes in regular communications with parents and caregivers (2011). A full 50% reported ability to explain how mathematics for elementary grades fit the library mission, compared to only 5% at baseline (2009, 2011). One key topic was the role of mathematics in everyday life. At baseline, only 11% reported ever discussing this with children (2009), but this percentage was found to be much higher (see Table 3) after exposure to MOTS.

LBIEs reflected that accompanying this change in practice was a change in their own abilities. At baseline, 5% reported being able to explain how mathematics offerings for grades K-6 fit the library mission, compared to 50% after exposure to MOTS activities (2009, 2011).

Table 3

Changes in Communication about Mathematics in Everyday Life with Children (2010)

Percent of total respondents (*N*=83)	Because of exposure to MOTS, I now talk about mathematics in everyday life with children....
8%	at least once daily
30%	about weekly
19%	about monthly
27%	less frequently than monthly
13%	never
2%	(no response given)

Note: Percentages do not add to 100 because of rounding.

Some LBIEs noted that they communicated more about mathematics because they now had a way to do so that meshed with their library work. For instance, assessing changes in communication about mathematics, an LBIE noted, "I [now] can talk about math without feeling/ acting like a classroom teacher." (2009). Traditional classroom teaching can be a pervasive model for how mathematics should be discussed, but one that may seem unconnected to the library; MOTS provided a relevant alternative.

Change in Beliefs and Attitudes about Mathematics

As Table 4 indicates, participating LBIEs reported considerable changes about the role of mathematics in the library when asked to compare their views before expo-

sure to MOTS to their present views. In addition, 90% reported gaining a more positive attitude toward mathematics because of their participation in MOTS activities (2011).

Table 4
Post-MOTS Agreement about LBIEs

	"Because of exposure to MOTS, I...." item used in a particular year's survey
91%	believe that librarians should learn more about integrating mathematics into programming for children (2010)
90%	believe that including more mathematics in their offerings is a strong priority (2010)
70%	have undergone a substantial change in ability to explain to children how mathematics is relevant to library use (2009)

Sustained Impacts of Exposure to MOTS Activities

Overall impacts sustained over the three years of surveys, with mathematics becoming integral to LBIEs' programs. Each year, about 90% stated that including more mathematics in offerings for the elementary grades is a strong priory; 50% reported going beyond MOTS activities to create similar mathematics activities; and just over 50% reported discussing the role mathematics in everyday life with children on a regular basis (2009, 2010, 2011). LBIEs surveyed did not *have* to use MOTS; they chose what to implement. Yet, despite almost no use of mathematics before using MOTS activities, a large majority, once exposed to MOTS activities, chose to integrate mathematics on a regular basis. When asked which factors contribute to their sustained use, the top two reasons each year were *their own commitment to offer mathematics to children*, and *interest/demand from children* (2010, 2011).

Discussion and Conclusion

MOTS offered various types of activities that engaged children with mathematics that is contextual, relevant, and accessible in out-of-school informal programs. LBIEs particularly valued the fact that they could integrate mathematics into their existing areas of strength and expertise, drawing upon the themes, projects, and ways of interacting with children that they have developed over time to address local interests and needs. If these LBIEs are representative of informal educators as a whole, they may have felt strongly from the start that children should succeed in mathematics. However, before encountering MOTS activities, LBIEs may not have seen themselves as capable of playing a role in helping children to realize that success.

MOTS activities enabled a very broad range of LBIEs to incorporate substantially more mathematics in their offerings and to model enthusiasm and positive attitudes toward mathematics; to support them in creating even richer learning environments for children, we had initially planned to offer ongoing professional development on mathematics content and pedagogy. Early in the project, we encountered several insurmountable obstacles. The most pervasive involved LBIE availability: even with the offer of release time covered by project funds, many LBIEs were not able to take time away from their library duties during their work hours; some worked under contracts that prevented job-related professional development outside of work hours. Those who were granted time for professional development often had to make hard choices.

For many LBIEs, offering activities to children is but one job component; they also develop book collections, provide reference services, catalog, maintain records, and stay current with the latest technology available at the library. Professional development relating to children's programming, never mind mathematics programming, was not always their priority. Thus, while the project succeeded in changing LBIEs' attitudes and behaviors, we were not able to explore supporting LBIEs in deepening their mathematics knowledge.

The MOTS project findings suggest that even without mathematics professional development for staff, out-of-school programs offer tremendous potential for engaging a diverse range of children in doing, discussing, and enjoying mathematics. With increasing numbers of children from non-dominant groups participating in out-of-school programs (Afterschool Alliance, 2012), more efforts are needed in order to identify strategies for leading informal educators to embrace mathematics, so that they can then pass on their enthusiasm to children.

With that in mind, we conclude by summarizing strate-

gies that emerged from the MOTS project and could be promising for the development of resources for other out-of-school realms:

Ground activities in authentic situations that informal educators find compelling. Activities should be designed to honor informal educators' areas of comfort, expertise, and passion—whether certain topics, types of programs, or ways of interacting with children.

Ground activities in what children find compelling. Children typically choose whether to participate in out-of-school activities. If children enjoy the offerings, informal educators will provide more. If mathematics is embedded in what children love, they are poised to appreciate mathematics,

Start with mathematics that informal educators know. Instead of asking informal educators to undergo a mathematics refresher course or require professional development that may not be feasible for them, support them in becoming more aware of mathematics they already do in everyday life and in making this mathematics more explicit for children.

Let informal educators lead. Informal educators, often from the same demographic as the children with whom they work, serve as role models and mentors. If they engage in mathematics activities and conversations directly with children, they demonstrate that mathematics is for everyone.

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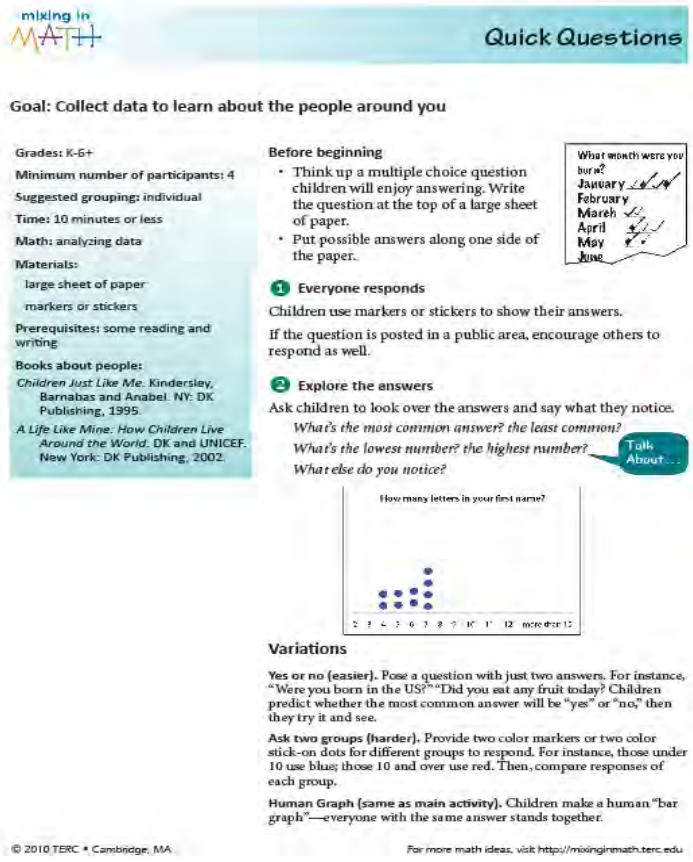
Discussion And Reflection Enhancement (DARE) Post-Reading Questions

1. The approach described in this paper is designed for informal education. Which aspects would work well in a school setting as well? Which would be less successful in most classrooms? Why?
2. Some educators attempt to engage children of different backgrounds in mathematics through use of word problems that incorporate names of children in the class (e.g., see Wager, 2012). How does this approach differ?
3. Why might informal educators who care deeply about children and want them to succeed academically avoid doing mathematics with children? What comparisons, if any, can you make between informal educators' attitudes toward mathematics and those of elementary classroom teachers?
4. What features of MATH OFF THE SHELF materials enabled informal educators to incorporate more mathematics?
5. Choose an activity from the project website (http://mixinginmath.terc.edu) and describe how you would use it with a group of children from many different backgrounds. How might you adapt the activity? Why do you think it would engage children? If you work with children, try out the activity.

Discussion And Reflection Enhancement (DARE) Post-Reading Questions (continued)

6. Find a different mathematics resource designed for after-school programs serving elementary grade children (for instance, look at http://www.sedl.org/cgi-bin/mysql/afterschool/curriculum-choice.cgi?location=by_grade&subj=m for some options). How does your chosen resource engage children from diverse backgrounds and/or non-dominant groups? How might you adapt the resource to draw on children's home cultures?
7. Browse a resource (e.g., Burns, 2004; Thiessen, 2004; Whitin & Whitin, 2004) designed to support integration of children's literature and mathematics and choose one idea from it. How is it alike and different from the approach described in this paper? In what ways does it draw in children from different backgrounds?

Appendix



mixing in MATH

Quick Questions

Goal: Collect data to learn about the people around you

Grades: K-6+
Minimum number of participants: 4
Suggested grouping: individual
Time: 10 minutes or less
Math: analyzing data
Materials:
large sheet of paper
markers or stickers
Prerequisites: some reading and writing
Books about people:
Children Just Like Me. Kindersley, Barnabas and Anabel. NY: DK Publishing, 1995.
A Life Like Mine: How Children Live Around the World. DK and UNICEF. New York: DK Publishing, 2002.

Before beginning

- Think up a multiple choice question children will enjoy answering. Write the question at the top of a large sheet of paper.
- Put possible answers along one side of the paper.

What month were you born?
January
February
March
April
May
June

1 Everyone responds

Children use markers or stickers to show their answers.

If the question is posted in a public area, encourage others to respond as well.

2 Explore the answers

Ask children to look over the answers and say what they notice.

What's the most common answer? the least common?
What's the lowest number? the highest number?
What else do you notice?

Talk About...

How many letters in your first name?

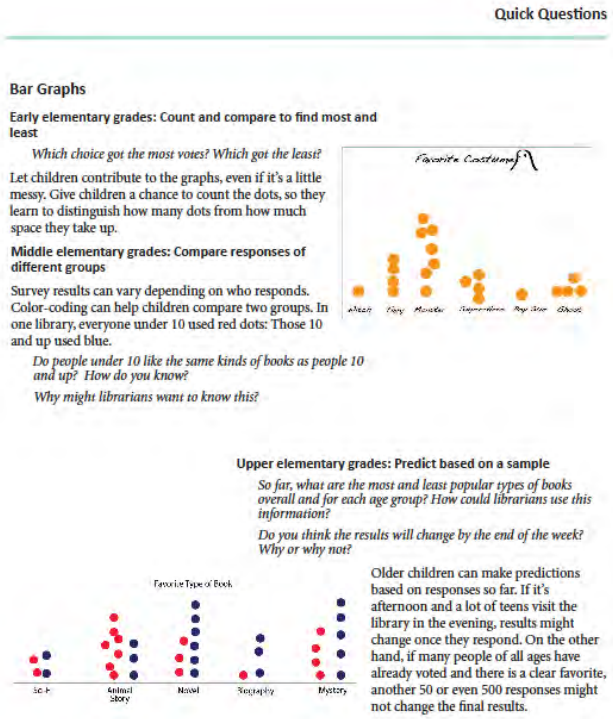
Variations

Yes or no (easier). Pose a question with just two answers. For instance, "Were you born in the US?" "Did you eat any fruit today? Children predict whether the most common answer will be "yes" or "no," then they try it and see.

Ask two groups (harder). Provide two color markers or two color stick-on dots for different groups to respond. For instance, those under 10 use blue; those 10 and over use red. Then, compare responses of each group.

Human Graph (same as main activity). Children make a human "bar graph"—everyone with the same answer stands together.

For more math ideas, visit http://mixinginmath.terc.edu



Quick Questions

Bar Graphs

Early elementary grades: Count and compare to find most and least

Which choice got the most votes? Which got the least?

Let children contribute to the graphs, even if it's a little messy. Give children a chance to count the dots, so they learn to distinguish how many dots from how much space they take up.

Middle elementary grades: Compare responses of different groups

Survey results can vary depending on who responds. Color-coding can help children compare two groups. In one library, everyone under 10 used red dots: Those 10 and up used blue.

Do people under 10 like the same kinds of books as people 10 and up? How do you know?

Why might librarians want to know this?

Upper elementary grades: Predict based on a sample

So far, what are the most and least popular types of books overall and for each age group? How could librarians use this information?

Do you think the results will change by the end of the week? Why or why not?

Older children can make predictions based on responses so far. If it's afternoon and a lot of teens visit the library in the evening, results might change once they respond. On the other hand, if many people of all ages have already voted and there is a clear favorite, another 50 or even 500 responses might not change the final results.