Mathematics at Play

Abstract: Based on interviews with 21 families, we found that school-aged children and their families engage in rich forms of mathematical reasoning as they engage in play and leisure activities at home. We present examples of the wide variety of activities and kinds of math reported, as well as an in-depth look at a few cases. From our results, we draw design implications for linking formal and informal mathematics learning.

Introduction

Although addressed by important visionaries in education (Vygotsky, 1967; Piaget, 1932), play and leisure are largely perceived to be orthogonal to children's learning, especially once children reach school age (Okan, 2003). Research suggests that play activities may be valuable for learning (Rieber, 1996), particularly in the domain of mathematics (Guberman & Saxe, 2000; Siegler & Ramani, 2008). However, relatively little research relates play and mathematics learning in the context of the home setting. The aims of this project are three-fold: First, we seek to investigate how families encounter and engage in mathematical practices during play and leisure activities. Second, we aim to provide a broad, cross-family account of the kinds of math involved in these activities, as well as an in-depth analysis within case families. Third, we hope to develop design implications from our results that bridge the informal mathematics learning we see in families with the formal mathematics in schools.

Method

21 families, who represented the racial and economic diversity of the San Francisco Bay Area, participated in semi-structured interviews as part of a larger study (Goldman et. al, 2006; Pea et. al, forthcoming). The interviews occurred in the home, lasted approximately two hours each, and centered on contexts in family life previously shown to be fertile for mathematical problem solving. The current analysis draws on this data set to specifically consider the many instances in the interviews where play and leisure organically came into conversation as families discussed mathematics. To conduct the analysis, we revisited our previously cataloged database to look at all the instances in which families discussed a problem they believed to have involved math, looking for instances that involved play and leisure as defined by Rieber (1996).

We coded each instance, noting the family, the members of that family participating in the activity, an overall summary of the activity, and the kinds of math that were involved. The play/leisure activities were broken into three categories: hobbies and projects, games, and informal sports related activities (i.e., activities related to sports but that were not being officially organized by a coach at the time). See Table 1 for a small sample of the full table of play/leisure activities reported that involved mathematics.

Table 1: A short excerpt of our Play and Leisure Analysis; includes hobbies and projects as well as games

Family Name	Who was involved?	What was the event?	Kinds of Math
Echevarria	Daughter	Inventing make-believe businesses	Arithmetic, Comparing Magnitudes, Decimals, Optimization, Proportional Reasoning
Pulepule	Mom, Daughters, Relatives, and Friends	Making Tongan mats	Arithmetic, Estimation, Measurement, Proportional Reasoning
Walters	Daughter, Son, Grandfather, and Grandmother	Playing bridge	Arithmetic, Logic, Probability
Muntz	Daughter	Playing *Neopets* game online	Arithmetic, Comparing magnitudes, Data analysis, Interest Rates

Case Studies

In addition to the cross-family analysis, we examined several cases in more depth. Given the space limitations of this paper, we highlight two of our examples.

Playing Neopets

The Muntz family includes the father, Donald, the mother, Nancy, and a 6th grade daughter, Erin. Like another middle school girl in our sample, Erin's plays *Neopets*, an online game where players care for computer pets. In this environment, players can buy things with *Neopoints*, which they earn by playing games. Erin buys things at

the *Neopoints* store, and then later sells them for a profit at an auction. The balance of *Neopoints* is kept in an online bank account, which earns interest. To earn *Neopoints*, Erin sends in the scores she received playing a game. She is only allowed to send in three scores per day, so if she gets a score of 100, she has to decide if later she is more likely get a higher or lower score, and whether to send it in. Erin says she thinks about her average score in making the decision. From this small excerpt from the data, we can start to link how Erin is using standard financial practices such as maximizing interest and profit to achieve her goals in the game.

Imaginary Businesses

In a second example, the entire family is involved in a play activity, supporting the middle school-aged daughter's mathematical activity. The Echevarria family is from Columbia. The mother has lived in the US for 14 years, the father for 19 years. Their two children—the younger 6th grade daughter Sabrina and the older 9th grade daughter Rebecca—were born in the USA. The dad noted how "Sabrina loves to set up businesses, here, at home," as she "goes off by herself" to create make-believe businesses. Sabrina described a recent example, a laundry business: "I have to set up everything, like a stand, and figure out what materials I will need, and make things on paper for it to work out. I have to figure out how much I have to have in my cash register, and to spend on things, for the business to work." When asked how she kept track of all of this, she replied: "I have different prices for different things to be washed - pants $3 and shirts like $2.99. And then from these prices I kind of figure out how much I'd need for washing machine costs. And how many people's things coming in I would need to make my business work." The family reviewed the list of businesses she had developed in this way: magic shows, laundry, bank, restaurant, grocery store, play house. Her father said: "She goes off all by herself until she invites us to the show or to buy things – she plays the lady who sells the tickets at the entrance and also plays the star of the show." These businesses have large socio-dramatic components: she dresses up, prices items, and requires her family to come and buy things.

Design implications

In this analysis we look specifically at play and leisure activities to understand how math is understood in the context of informal and fun activities. Family members discussed hobbies, projects, games, and sports. We found that these events involve various family members and a range of math, including 2D and 3D geometric reasoning, estimation, arithmetic, probability, and proportional reasoning. The diversity of math-related problem solving in these activities, their repetitive nature, and the co-participation of family members make them ripe contexts for math learning, especially since these play and leisure activities are a matter of pleasure for the family members. Activities such as these are mathematically engaging, and in some cases, have links to other STEM fields such as engineering, science and technology.

The analysis of play and leisure is helpful as we move into creating designs for tools that encourage mathematical identification, problem solving, and support. It is also instrumental for building our design and cross-setting research work in and between homes and schools. We see more profound opportunities to craft boundary-crossing supports for mathematizing experience and supporting mathematical alignment across home and school settings. Our upcoming work builds off of these results, providing tools for family members to identify and treat daily activities in math-rich ways, raising awareness of math in family life and encouraging family conversations and problem solving with mathematics. For schools, we will design resources for upper elementary and middle-school that help teachers recognize and utilize families as resources for mathematics learning and thinking.

References

Goldman, S., Martin, L., Pea, R., Booker, A., & Blair, K. P. (2006). Problem Emergence, Problem Solving, and Mathematics in Family Life. *Proceedings of the 7th International Conference of the Learning Sciences,* Bloomington, Indiana. 1088-1093.

Guberman, S. R., & Saxe, G. B. (2000). Mathematical Problems and Goals in Children's Play of an Educational Game. *Mind, Culture, and Activity*, 7(3), 201-216.

Okan, Z. (2003). Edutainment: is learning at risk? *British Journal of Educational Technology*, *34*(3), 255–264.

Pea, R., & Martin, L. (forthcoming). Values that occasion and guide mathematics in the family. In O'Connor, K., & Penuel, W.R. (Eds.), *Research on Learning as a Human Science.* New York: Teachers College.

Piaget, J. (1932). The Moral Judgment of the Child. Glencoe, Ill.: Free Press.

Rieber, L. P. (1996). Seriously considering play: Designing interactive learning environments based on the blending of microworlds, simulations, and games. *Educational Technology Research and Development*, 44(2), 43-58.

Siegler, R. S., & Ramani, G. B. (2008). Playing linear numerical board games promotes low-income children's numerical development. *Developmental Science*, 11(5), 655-661.

Vygotsky, L. S. (1967). Play and its role in the mental development of the child. *Soviet Psychology*, *5*(3), 6–18.