Making math learning social and familial: the promise and problems of mobile devices

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Abstract: In order for families to engage in math play, we created several mobile applications that were designed to maintain fidelity with family practices while simultaneously providing opportunities for mathematical learning. We explain our reasons for developing apps that rely on social models of play, outline design principles that emerged from research with families, and share the successes and issues that arose in field tests. While the apps provided opportunities for rich math talk in the families, the mobile platform came into conflict with mobile users' tendencies toward individual time with their devices. The results raise concerns about mobile affordances and uses as collaborative learning devices in families.

Introduction

When surveying the education technology landscape, we began to notice that a majority of apps and games for children have been designed for individual user play. With technologies such as Intelligent Tutors (Koedinger, Anderson, Hadley, & Mark, 1997) we have made great strides in creating effective learning technologies that center around the individual learner and her progression through developmentally sequenced, disciplinary-based learning activities. Our project looked beyond school-based learning, conducting research to better understand math problem solving in families, to see if there was a way to design for social learning experiences in the spaces side of school. We discovered that families engage in a great deal of problem solving together. Our project to develop math apps attempted to maintain fidelity with the social and interactive opportunities that families engaged. The goal was to have children, friends, siblings, and parents play math games together in a way that corresponded with, and drew on, the culture of the family (Martin et al. 2009). Based on this goal of finding and designing learning opportunities that would have fidelity with family practices, we undertook and started developing Go Math! iPhone apps.

We conducted basic research on families to understand what actually happened that was mathematical in the course of their daily activities. We found that math inside families was not like math in school (Esmonde et al. 2013). Mathematically relevant problem solving in families was social in nature. Math at home was connected to values and needed problem solving, and was more about accomplishing what needed to be done than it was about getting the math correct.

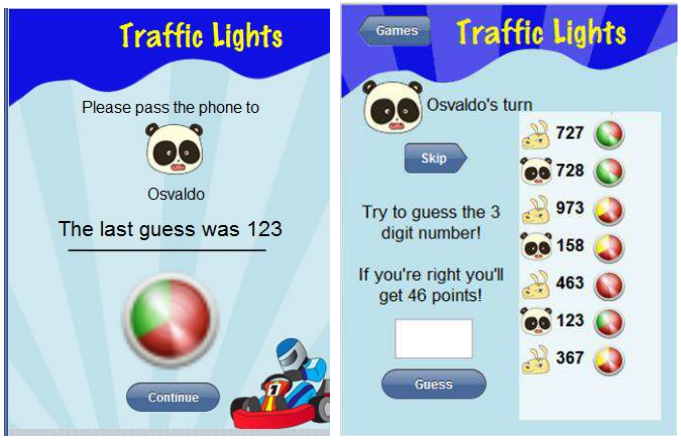
Learning about what mathematics looked like inside families led us to think about how to build on the families' day to day math engagements. We took our findings and created a set of design principles that would guide our development of technology for family learning (Alexander et al., 2010). Our team wanted to make sure that the app environments: 1) were driven by the situations families find themselves solving problems in, 2) promote the enjoyment of math, 3) demonstrate the value of using math, 4) be compelled by what matters to families, considering the family as a social unit, and 5) serve as a complement to the math learned at school. Because the families were often on the move and extremely busy, the environments also should take advantage of the affordances that mobiles provide. Overall, these principles were meant to cleave with, rather than contradict family life and serve as a blueprint for much of our application design work. One application that rose from this blueprint, GoRoadTrip, serves as an example of our design and the issues that we have confronted.

GoRoadTrip: Building on Basic Research and Design Principles

GoRoadTrip has evolved into a mini suite of games that families can play at home or while taking car trips. Playing games is a topic that came up often with families in how they would promote enjoyment of mathematics with their children, and something that parents valued. The scenario of a car trip also came from families who discussed how they entertained themselves while on long trips.

When we began designing GoRoadTrip, the ubiquity of cell phones among children, particularly "internet-enabled smartphones", was low. Therefore, to enhance the adoptability and reach of GoRoadTrip, we decided that, inside each game and during game play, one phone could be shared by multiple copresent players. Having a shared phone made the most sense, as it focused our designed experience on family interactions. The applications simply direct each family member to take their turn and pass the phone to another player (see Figure 1). The GoRoadTrip application not only directed the user to pass the phone but also relied on the mechanics of the game to provide good reasons to do so. For example, in *Traffic lights* users either work

together or ask one user to enter a secret 3-digit number. After providing a secret number the remaining family members take turns trying to guess the number based on a history of guesses given by the family members (See Figure 2).



Figures 1 and 2. Screenshots of *Traffic lights* asking to be passed and displaying families working together.

Every time a member of the family guesses a number, feedback is given to that member about their guess. Players receive three different types of feedback on the 3 digits that they guessed. Each member of the family also though receives the feedback that other family members have gotten, which allows them to collaborate on solving the secret number. This game is inspired by both "Bagel, Pico, Firme" and Mastermind and follows our mission statement by promoting the enjoyment of math, using the affordances that the mobile provides, and serving as a complement to school.

Having built a prototype, we then conducted user tests. Initial pilot testing involved videotaping families while they used GoRoadTrip in the car. We documented that children would pass the phone around while playing the games and work together to try to solve the problems. Older siblings taught younger siblings how to play the games, and they would often collaborate both on the screen and off the screen while having discussions about the math and their possible solutions. Parents engaged enough with the students in the car that we had to include a warning not to touch the game while driving.

Data analysis indicated that the socially oriented mobile applications have both promising and troubling aspects. On the positive side, they do generate conversation and activity with math among family members. On the troubling side, children have sometimes found it difficult to get others to play with them when they are taking turns, and several have indicated that they play the games primarily against themselves. Since we began app development and the studies, patterns of mobile use in families have emerged such as the "pass back" phenomenon, where parents give the child their mobile so they can drive in peace or have a few minutes to do something else other than engage the child. We are concerned that the social requirements of our mobile apps are in conflict with the trends toward individual use. These contradictions leave learning technology designers with dilemmas to solve: if social math is possible and somewhat natural way to learn in families and mobiles are becoming ubiquitous and fitting the activities and lifestyles of families, how do we actually design opportunities for collaborative learning in consideration of people's tendencies to seek out mobile time as individual time? We hope to drive this point as well as provide more first hand evidence in our poster sessions.

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Acknowledgments

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