Fostering Math Engagement with Mobiles

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Abstract: Everyday life is a rich context for mathematical thinking and learning across a wide range of activities, yet students' everyday mathematical competencies rarely see light in school. Mobile devices, such as smartphones and media players, can provide a much needed technical infrastructure for linking the mathematics of school with students' lives and experiences outside of school. In support of this claim, we present results from a study where students used mobile devices to engage in mathematical problem solving, with problems drawn in part from their out-of-school interests and experiences. Findings suggest that mobile devices, properly deployed, can help provide ease the process of making connections between the informal competencies that students bring with them to school, and the disciplinary competencies that schools most hope to foster.

Introduction

Everyday life is a rich context for mathematical thinking and learning across a wide range of activities, from dieting (de la Rocha, 1985), to sports (Nasir, 2000), to personal finance (Martin, Goldman, & Jiménez, 2009). Yet students' everyday mathematical competencies rarely see light in school. There are many calls in the literature for researchers and educators to bridge the gap between students' out-of-school experiences and the mathematics of school (e.g., Civil, 2002; Nasir, Hand, & Taylor, 2008). Yet there are a number of pervasive barriers to bringing together the mathematical thinking and learning that takes place across these distinct contexts. Among these barriers are:

- Differences between in-school math practices (e.g., abstract, precise, content driven, extrinsically evaluated) and out-of-school math practices (e.g., concrete, problem- and values-driven, intrinsically evaluated) (Esmonde et al., 2012)
- Student and teacher beliefs about "what counts as math" typically privilege in-school content and contexts (Abreu & Cline, 2003; Martin & Gourley-Delaney, 2011)
- Lack of teacher knowledge of mathematics in students' lives outside of school (González, Andrade, Civil, & Moll, 2001)
- Lack of student skill in mathematizing their out-of-school experiences (cf. Lesh, 2003)

Typically, the only means for connecting these distinct contexts, and for carrying ideas, artifacts, and representations across the in-school / out-of-school divide, is to rely on students and teachers. While this can be successful, in the absence of a dedicated team of researchers or other support staff, efforts will remain largely ad hoc and idiosyncratic. We argue that mobile devices, such as smartphones and media players, can provide a much needed technical infrastructure for linking the mathematics of school with students' lives and experiences outside of school. Mobiles have unique potential to erode the barriers identified above. In support of this claim, we present results from a two-week study where students used mobile devices to engage in mathematical problem solving, with problems drawn in part from their out-of-school interests and experiences.

Theoretical Framework

Mobile devices such as smartphones and media players are attractive educational technologies for a number of reasons: they are relatively low cost, have low barriers to use, are increasingly powerful, and are increasingly ubiquitous in the lives of young people. A number of innovative research and development studies have shown the power of mobiles for creating opportunities for deeper engagement with core disciplinary practices (Roschelle et al., 2010; White & Pea, 2011; White, Wallace, & Lai, 2012). Others have looked at the role of mobiles in informal mathematics learning outside of school (e.g., Jimenéz et al., 2010). We focus here on the potential of mobiles to bridge the divide between school math and students' knowledge and experience from outside of school.

In doing so, we leverage four characteristic informal digital practices associated with mobile devices. Specifically, mobiles enable 1) *capturing and collecting* photos, videos, and audio; 2) *communicating and collaborating* via text, email, phone, and video chat; 3) *viewing, consuming, and analyzing* text and media acquired from the internet or from peers; and 4) *representing and creating* new media and representations using a variety of apps (White, Booker, Ching, & Martin, 2012). We see in these four practices parallels with core mathematical practices of data collection, argumentation, and the creation, critique, and analysis of multiple representations.

Although our work is at an early stage of development, we draw inspiration from a thread of research that spans the learning sciences on how to build new, disciplinary knowledge from students' existing competencies, whether those competencies lie in everyday physics (Bryce & Macmillan, 2005), verbal language play (Lee, 2012), or videogames (Gee, 2007). We see students' informal digital practices as areas of strength that provide entry points into mathematical practices. Moreover, because mobiles literally travel with students as they move across the in-school out-of-school boundary, the digital artifacts that students collect and create can also move across these spaces.

Our research is in the initial stages of a design based research cycle. The work presented in this paper does not represent a "final product," and does not reach the design goal of integrating in-school and out-of-school mathematical practices. Instead, it offers an exploration of the potential of mobile devices to support bridge-building between informal and formal mathematical practices, and as such offers a platform for further research and development.

Methods

Participants and Research Site

The study took place in a diverse urban school which serves a largely low income student body (86% are eligible for free or reduced price lunch). A mixed-age group of 19 sixth through eleventh graders participated in the study for one hour per day over a two week period. The school emphasized project based learning in several areas of the curriculum, but mathematics was taught traditionally. Students participated in lieu of their homeroom period.

Design and Procedure

In overview, the study proceeded as follows. Each student was loaned an iPod Touch for the duration of the study. They were encouraged to take the devices home with them and to customize content and settings as they saw fit. We began the study with activities designed to orient students to the devices and their capabilities, especially with regard to the four characteristic informal digital practices we identified: *capturing and collecting*; *communicating and collaborating*; *viewing, consuming, and analyzing*; and *representing and creating*. During the first week of the study, we placed mathematical content first, focusing students' attention on linear equations and linear phenomena. We then asked them to collect photo and video examples of linear variation, using their devices, to bring into the classroom context (see below for more detail). During the second week, we let students' interests lead. We asked them to conduct a mathematical investigation of their own choosing, using their devices to collect and analyze data, to collaborate with peers, and to represent their results.

Results

An initial question in our analysis was, how effective were the devices in bridging students' informal (out of school) and formal (in school) experiences? The devices themselves were part of a school-based intervention: would students treat them as school-like devices, or would they modify and customize them as they might their own devices? We found some evidence that students easily bridged the dual purposes and possibilities for the devices. Of the 220 photos that students took with the devices, two-thirds were personal photos, with the remainder taken as part of school-based activities. The same ratio held for the 52 videos that students took. About half of the students customized their device by changing the background photos and/or downloading an app.

Second, we asked whether students saw the mobile devices and activities as supporting them in learning and doing mathematics. In an anonymous survey at the end of the two weeks, students were very positive about their experience. All students agreed or strongly agreed with the statement, "I learned some new ways to use an iPod during these activities," and 14 of 15 respondents agreed or strongly agreed with the statement, "I learned some new ways to use math during these activities." Data from interviews suggest a similar pattern, where students felt that they learned new ways to use the devices that supported mathematical thinking and learning.

We also looked for evidence within the activities themselves that students were able to actively participate in tasks that asked them to work across the in-school out-of-school boundary. We now turn to a brief description of one such activity that took place during week one, on day three of the study. Students were given the assignment of taking their devices home or into the community and taking a photograph of something that showed a line. When they returned to class, they used an app to send the photo to the researcher's computer (and to a classmate, if they chose to). The second author, White, who was leading the activity that day, chose a photograph of window blinds to project onto the whiteboard (see Figure 1). He then used a white board marker to draw a line superimposed on top of the image, following one of the white lines in the image.

The front of the room computer and projector were reset to display a shared coordinate plane from the *Graphing in Groups* classroom network software on the whiteboard (White, Wallace, & Lai, 2012). In dyads, students loaded the *Graphing in Groups* client app on their devices. This allowed each student in a dyad to control one of the two points that jointly define a line. Their task was to construct a line that matched the line drawn on the whiteboard, representing the line from the image of the blinds (see Figure 1).

The teacher/researcher (White) then asked students, "What do you notice about those equations that's different from these equations," pointing to equations from the previous session that had whole number coefficients on the x term. One student replied, "They're wholes," and then when prompted to clarify, "they're fractions." White then began to circle the equations for the various lines that student dyads had made, naming them as he went and writing them on the board: $y = 1/18x + 1.53$; $y = 1/5x$; $y = 1/10x + 2.5$; $y = 1/10x + 2$.

The variety of fractional coefficients (less than one) provided a set of near contrasts for students to compare. These were then, in turn, contrasted with lines with coefficients larger than one. The mapping between the equations and their graphed lines, represented multiply on screen and on the board, provided the context for a discussion of the correspondence between slope of a line and the size of a coefficient. Within this instructional context, students had a context for interpreting the slope (angle of the blinds), and knew the source of the variants (themselves and their classmates). The activity culminated in a discussion of the "rise over run" interpretation of the slope, an idea that was familiar to some, but not all of the students in the mixed age group.

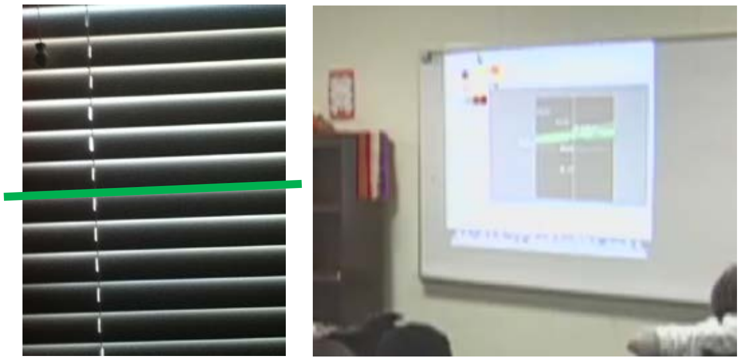

Figure 1. On the left, a student's photo of blinds, with a line superimposed in green. On the right, a *Graphing in Groups* coordinate plane projected on the board, so that students could try to match the drawn line.

Three things are evident from this activity. First, there was variation in the lines that students created to match the drawn line. In some school math contexts, this variability would indicate error, lack of precision, and need for correction. In this case, the minor variations were not problematic, likely because of the informal nature of the stimulus (a student's photo) and the approximate nature of the line matching activity. As such, the variability could then be seen as a resource – students generated similar but contrasting exemplars, and the teacher could help the class to abstract over these variations (in coefficient) to induce the relevant invariant properties (the correspondence between coefficient and slope). By creating space for student-driven variability, not only in the lines drawn but also in the photographs taken, there was greater opportunity for abstracting over cases.

Second, students had opportunities to contribute to the activities in ways other than speech. Even in this brief example, students contributed in three ways: by taking and sharing photos, by drawing lines with *Graphing in Groups*, and by raising their hand to speak.

Third, the activity transitioned easily into a second iteration. For the following day, we asked students to take a brief (10 second) video of something that they thought was changing in a linear fashion. In small groups, students segmented their videos into one second increments, measured the displacement of the relevant object, recorded the time and corresponding displacement in a data table (within a spreadsheet application on the device), and finally created a graph of the motion. As a whole class, students shared and discussed their videos and the corresponding tables and graphs. Discussions included whether or not the motion was linear and, if so, what the slope, intercept, and equation of the line would be. Here the notion of slope was generalized beyond its visual interpretation (i.e., steepness) to represent rate of change.

Discussion and Conclusion

We make no claim that the activities we present here represent an ideal or optimal learning environment. Instead, we argue that our data offer a proof of concept that mobile devices, properly deployed, can help provide technical infrastructure to ease the process of making connections between the informal competencies that students bring with them to school, and the disciplinary competencies that schools most hope to foster. As such, our findings provide warrants in support of further study of mobiles as bridging devices. Our work in this area continues as we move to incorporate more complex and substantive issues from students' lives into the mathematical work of the classroom.

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