Disrupting Learning: Changing Local Practice for Good

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Abstract: The papers in this symposium explore the concept of disruptions as an analytical concept for investigating how individual learning and changes in local practice mutually influence each other in designed learning contexts. Disruptions are rearrangements, temporary or sustained, of typical practice, meaningfully experienced by participants. The papers present data from a variety of studies investigating middle and high school mathematics education settings (teacher professional development, a geometry design study, museum field trips) as comparative cases for exploring the idea of disruptions. We explore how disruptions to typical practice in terms of discourse, authority, participation frames, material and representational tools, and spaces and modes of learning are taken up, adapted, or rejected by learners, and how this informs design.

Symposium Overview

Sociocultural theories of learning value the contexts (e.g., Greeno & MMAP, 1998; Rogoff, 2003) or communities of practice (Lave & Wenger, 1991; Wenger, 1998) where learning occurs, but ways of understanding individuals' learning in concert with changing practice are still under development (Cobb, Stephan, McClain, & Gravemeijer, 2001; Engeström & Sannino, 2010; Hall & Greeno, 2008). This problem is particularly salient in settings designed specifically for learning, where students and teachers are developing their own practices within the learning context.

The papers in this symposium explore the concept of *disruptions* as a productive analytical concept for investigating how individual learning and changes in local practice mutually influence each other in designed learning contexts. We view disruptions as rearrangements, temporary or sustained, of typical practice, meaningfully experienced by participants. In general, disruptions may originate unexpectedly from external sources (e.g., an unscheduled fire drill during class, Rosebery, Ogonowski, DiSchino, & Warren, 2010), emerge from the needs or routines of ongoing practice (e.g., groups from different scientific disciplines interact to create new methods of analysis, Hall, Stevens, & Torralba, 2002), or result from designed interventions (e.g., leveraging rather than silencing students' counterscripts in classroom instruction, Gutierrez, Baquedano, & Tejeda, 1999).

Each of the papers presented here address disruptions that were created explicitly by design, targeted the norms and practices of typical classroom mathematics, and had diverse results for participants, their activity, and our understanding of their mathematics activity and learning. The authors all treat their study sites as intact activity systems, and the disruptions as consequential to how participants have access to and engage in the practices of these settings, and their learning. The findings from these papers, and the discussion following their presentation will contribute to theories of disruptions or changes in practice, and raise implications for the design of learning settings.

In the first paper, Munter, Heyd-Metzuyanim, and Greeno describe an episode of professional development and the resulting lesson of an algebra 2 teacher. The teacher attempted to disrupt the prevailing authority norm in the class by not telling whether the students were right or wrong. The authors found that this disruption was largely resisted by students, and was perhaps incompatible with other, aspects of the classroom setting that were left intact. In the second paper, Ma reports on a design which relied on a disruption to geometry's typical paper-and-pencil scale to strip the seventh grade class setting of established school mathematics tools and embodied dispositions, inviting students to engage out-of-school resources for learning and doing mathematics. She describes some ways in which this disruption supported a hybrid learning setting where students invented new tools for geometry problem solving, but also interrogates tensions and missteps that arose in the design and implementation. Finally, Kelton investigates middle school mathematics classes' field trips to a museum mathematics exhibit called *Math Moves!*, that explores ratio and proportion. These fields trips are disruptions to school mathematics in the sense that the routines and spaces of schooling change, but the exhibit itself disrupts the formalisms and representations of classroom mathematics in favor of multi-modal and multi-party explorations. She considers how the disruptive qualities and characteristics of this field trip and the exhibit flow into classroom learning, sometimes even before the visit itself.

By treating various aspects of designed mathematics learning settings as disruptions, this collection of papers provides a diverse set of cases for comparing and contrasting some possible types of disruptions, different dimensions (borrowing from Munter et al.'s paper) of classroom mathematics that might be disrupted, how they reorganize (or fail to reorganize) activity, and how they change individuals' participation and learning. This symposium will include three paper presentations, and comments from two discussants, Rogers Hall and Melissa Gresalfi. Hall's extensive work on disruptions in professional workplaces and the interactions between professional disciplines (e.g., Hall & Horn, 2012; Hall, Stevens, & Torralba, 2002) will provide a contrasting perspective from Gresalfi, whose research is more focused on classroom settings, and takes a sociocultural perspective in considering issues of mathematics disposition and identity, opportunities to learn, and equity (e.g, Gresalfi, 2009; Gresalfi & Cobb, 2011). There will also be time for audience-driven discussion.

Designing for Disruption Through Misaligned Frames

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Classroom life is usually a highly stable and routinized type of social practice (Cazden, 2001; Mehan, 1979). Though the teacher may be one of the leading agents that can influence it, it also has 'a life of its own' in the sense that it encompasses the whole set of expectations of the students, and the ways that they have become used to participating in the social activity called 'a mathematics lesson.' Although the differences in authority distribution between different instructional models (e.g., direct instruction or dialogic instruction) is fairly clear, how teachers and students make the transition from one to the other is not (Adler, Ball, Krainer, Lin, & Novotna, 2005; Goldsmith & Schifter, 1997; Staples, 2007). What is certain is that the transition is challenging (Hufferd-Ackles, Fuson, & Sherin, 2004), in part because the attribution of mathematical authority is just one in a complex system of variables, including the nature of classroom discourse (likely driven by teachers' questions, at least initially) and the nature of mathematical tasks—all situated, of course, in a broader social and cultural context (Depaepe, De Corte, & Verschaffel, 2012). And, shifting the distribution of authority likely requires disrupting all classroom participants' expectations for the roles that students and teacher will play—which become increasingly ingrained with each school year (Hammer, Elby, Scherr, & Redish, 2005).

In this paper we examine the attempt of one U.S. public high school mathematics teacher (pseudonym Mrs. Q) to disrupt the "authority norm" (Depaepe et al., 2012) during one lesson in her algebra 2 classroom—an act that was the result of her professional development and co-planning work with the first author (Chuck). Of course, significant shifts in students' expectations for how they will do things in the classroom are not likely achieved in a single day. But, by all accounts—both the teacher's and ours—the lesson was not even the modest success that it was imagined in planning. To explain that result we examined two sets of interactions—those between the students and Mrs. Q (during the lesson), and those between Mrs. Q and Chuck (during the lesson planning) with respect to how individuals were framing (Hammer, Elby, Scherr, & Redish, 2005) their roles, the mathematical tasks, and the intent and nature of classroom discourse.

In the second half of the 2012-2013 school year, Chuck began working with Mrs. Q, a high school mathematics teacher in her ninth year at the school, on identifying ways to employ more Accountable Talk (Michaels, O'Connor, & Resnick, 2008) in an algebra 2 classroom comprised of students who had previously been identified as struggling and assigned to a 'double-block' (90 as opposed to 45 minutes) mathematics class. The professional development (PD) consisted primarily of co-planning, reflecting on the execution of lessons, and examining transcript from MRS. Q's lessons.

During the third PD session, after analyzing a transcript from a previous class, Chuck asked MRS. Q whether she finds that her students often ask her if their solutions are correct. She responded that her students do it "*const*antly," suggesting (and lamenting) that they want immediate validation or they will stop working, and that "we as educators must have taught them to do it"—through teacher-centered instruction, "we've made them insecure as to what they're doing. They're going to feel like they're always wrong." In response to what she had identified as a challenge in her class's patterns of discourse and what she perceived as her students' expectations regarding her role, Chuck challenged her to attempt to refrain from telling students whether they are right or wrong. She said she would try, but predicted that she would have "mutiny" since the students would view her attempt to disrupt the authority norm as "not teaching." This episode set up the two episodes that were the foci of our analysis.

We (the researchers) analyzed transcripts from audio recordings of two sets of interactions—the fourth professional development/planning session on Monday, February 18 and the lesson on the following Tuesday. In the first, Mrs. Q and Chuck co-planned a lesson that would focus on identifying the zeroes of polynomial functions (with an emphasis on factoring). For the day's primary task, they chose "What are the zeroes of $f(x) = 6x^3 - 19x^2 - 9x + 36$?"—which, in factored form, is $f(x) = (x - 3)(2x - 3)(3x + 4)$—and identified at least two strategies that students would likely employ (trial and error and graphing it on a calculator to find x-intercepts). They imagined that, employing either of those methods to find an initial root, students might then write a factor 'around' that root and use long division to rewrite f(x), e.g., $f(x) = (x -3)(9x^2 + 6x -12)$ (a procedure that Mrs. Q had demonstrated in the previous day's lesson). In order to set up that group work and the eventual discussion of students' strategies, Mrs. Q and Chuck decided that the warm-up launch would include asking students to "find the zeroes of the quadratic function by factoring: $g(x) = x^2 -7x + 12$," to promote factoring polynomials for a purpose (finding the roots) and to increase the likelihood that students would write a binomial factor for the first root they identify in the day's primary task (likely $x = 3$).

In the lesson, Mrs. Q posed a slightly modified version of the planned warm-up task: "Solve $x^2 -7x + 12 = 0$." When some of the students used the quadratic formula, Mrs. Q took the strategy up for the whole class, prompted them for which numerals to write where and the results of each calculation, and arrived at the solutions, which Mrs. Q told them are also referred to as "roots" or "zeroes."

After similarly completing two more warm-up tasks that Mrs. Q and Chuck had planned, Mrs. Q asked students to work on the day's primary task in groups. During that 45 minutes of group time, students made little, if any, progress in solving the task. At one point, Mrs. Q visited a group whose idea was to use the quadratic formula. She said, "this is called the quadratic formula, so it has to be used for a quadratic equation. Is that a quadratic equation which I gave on your paper?" and then asked what they might do instead. When the students remained puzzled, she continued:

MRS. Q:	You've not done this before. I'm trying to get you to use your tools to hook 'em all together, to be able to do this.
FS:	You should give us an example.
Mrs. Q:	Well, then I'm not trying- I'm not getting you to *think*. You're trying to find the zeros so what does it mean- I'm gonna address all, all, three groups, okay? [To the whole class] On this problem, I'm not telling you how to do it, okay, and you haven't done one precisely like this, so… You're tryin to find the zeros. I'm not asking for an answer right now, I'm asking you to think, "What does it mean to be a zero of a function?" You can think back to the warm up, you can think back to different things…What does it mean if something is a zero of a function? (7 sec.)
MS:	Uh… X?
Mrs. Q:	I'm not asking you for an answer, I'm trying to get you to think about it so you can start answering this problem.
Mrs. Q:	[15 seconds later, repeated question for one group] What does it mean to be a zero of a function?
MS:	Zero.
MS:	Nothin'.
MRS. Q:	Okay, zero is an answer, sure. What, okay, so, what does a zero look if you have a graph? Where do you find them?
Chris:	Uh, right and left.
MRS. Q:	Okay. So, you're trying to find the zeros of that function. What kind of function is that on your paper?
Chris:	A polynomial.
MRS. Q:	It *is* a polynomial. Absolutely. What degree is that polynomial on your paper?
Chris:	Um… cubed?
MRS. Q:	Okay, so how many- how many zeros should you have?
Chris:	Three.
MRS. Q:	Okay. So, can you think of a way to find *any* of them?
Chris:	Uh, don't we got- uh, we got the zero property, uh, to get three zeroes.
Matthew:	I don't know, Mrs. Q, you gotta help us.

Mrs. Q provided hints (e.g., "What degree is that polynomial?... so how many zeroes should there be?" "If you graph it, don't you think you can find a root by the same procedure [as in the warm-up]?") until the students graphed the function and identified (3, 0) as one root. Then after more hints, Matthew divided f(x) by $(x - 3)$, Mrs. Q suggested that others do that, and students struggled to do so, until Mrs. Q posed the 'exit slip' task with two minutes remaining in the lesson, with no discussion of strategies, or even a statement of the solutions to the day's primary task. Throughout the lesson, students complained about Mrs. Q not telling them if they're right or wrong and not giving them examples of solutions that they could follow.

In our analysis of transcript of the preceding day's PD session, we used the notion of 'frames,' borrowed from sociolinguistic and situated cognition research (Hammer, Elby, Scherr, & Redish, 2005; Tannen, 1993). Hammer et al (2005) defined frames as "an individual's interpretation of 'what is going on here'" (p. 98). In their co-planning, we looked for evidence of Mrs. Q's and Chuck's interpretations of 'what is supposed to go on there [in the classroom].' In examining this lesson, and in particular in trying to understand what went wrong (or differently than envisioned in the planning session), we considered three dimensions of the classroom activity system drawn from research in mathematics classrooms: distribution of authority (Lampert, 1990; Rogoff, Matusov, & White, 1996); the nature of classroom discourse (Thompson, Philipp, Thompson, & Boyd, 1994); and the nature of the mathematical tasks (Stein, Grover, & Henningsen, 1996; Smith & Stein, 1998)—each with distinct 'opposite ends' representing different forms of instructional practice or epistemic stances about mathematics, between which are points of transition.

In line with Rogoff et al.'s (1996) perspective, we viewed a transition along the first dimension, distribution of authority, as a shift from approaching classroom learning as a one-sided process (either adult-run or children-run—but, in this case, most likely the former) to a shared endeavor in which teacher and students mutually engage. For the second, classroom discourse, we draw on the work of Thompson et al. (1994), who articulated different orientations in the discourses of two teachers' classrooms—calculational and conceptual. "The first teacher's goal was for students to solve the problem and share their procedures; the second teacher's goal was to create an occasion for students to reason and to make their reasoning public" (p. 87). We viewed the last dimension, mathematical tasks, as a potential shift from "low-level" to "high-level" tasks as defined by Stein and colleagues (Stein, Grover, & Henningsen, 1996; Smith & Stein, 1998), where the former includes tasks aimed at memorization or fluency with procedures but without making conceptual connections, and the latter includes tasks that promote understanding procedures conceptually or provide opportunities to solve challenging, ambiguously defined problems without the suggestion of a particular procedure or path to a solution.

We concluded that Mrs. Q's disruption was along only one of the three dimensions described above—the distribution of authority. The role in determining correctness had been shifted, but the tasks remained focused on using procedures to produce solutions, and the talk about the work remained calculational in nature. For example, instead of posing the first task as planned, "Find the zeroes of the quadratic function by factoring: $g(x) = x^2 - 7x + 12$," Mrs. Q. asked students to "Solve $x^2 - 7x + 12 = 0$." The planned version was intended to afford opportunities to make connections between a graphical representation of the functions roots and making sense of two factors' product being zero (often referred to in Mrs. Q's classroom as "ZPP," or the "zero product property," which Chris was referencing in the transcript above). But the restated version oriented students to using a different procedure—the quadratic formula, which did not provide an opportunity to use factors, and could not be used (as a first step) on the cubic later, though some students thought it could. Without concomitant shifts in these other, related dimensions of the classroom activity system, what was previously a relatively coherent system was rendered non-sensible by an attempt to disrupt the authority norm, particularly from students' perspectives (e.g., "You should give us an example"; "Mrs. Q, you gotta help us").

The other layer of our analysis revealed that the lack of success of the disruption was attributable, in part, to a misalignment in the ways that Mrs. Q and Chuck had framed the lesson. Similar to the distinction quoted from Thompson et al. (1994) above, Chuck's view of what was supposed to go on was a sense-making endeavor, in which students would draw upon current resources to generate strategies for solving a problem—one that promoted making conceptual connections. For this, students would need to be supported in engaging meaningfully in the tasks through talk of a conceptual (and not merely calculational) orientation, including ensuring that students understood what the problem was asking (e.g., a brief conversation about what "zeroes" are; Jackson, Garrison, Wilson, Gibbons, & Shahan, 2013). On the other hand, Mrs. Q likely framed the lesson as a series of activities through which students would formalize a procedure for identifying the (real) roots of a polynomial function. Within such a framing, Mrs. Q's task and talk choices make sense, revealing the incompatibility of the disruption with both the other dimension of the system and with Mrs. Q's frame.

Disruptive Scales in 7th Grade Geometry: Designing for Productive Hybridity

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In this design study a class of 7th graders constructed and worked with geometric objects at large scale, outside on a soccer field, using everyday materials such as ropes and lawn flags. The instructional setting was called "Walking Scale Geometry" (WSG). The premise behind the WSG design was that students learn mathematics best when they can connect to and build on prior experiences and knowledge (Civil, 2002; Gravemeijer, 1999), and that these should include both in- and out-of-school "funds of knowledge" (González, Andrade, Civil, & Moll, 2001) or "repertoires of practice" (Gutiérrez & Rogoff, 2003). From here on, I will refer to these simply as "resources." Instructional settings that incorporate and leverage students' recruited resources are often described by researchers as *hybrid*—classroom and disciplinary practices interface with home or community practices to produce a new, transformative learning setting (Gutiérrez, Baquedano-López, & Tejeda, 1999). Moreover, when instructors are careful to design learning settings that leverage students' known (by instructors) or unexpected resources, these settings become more productive for all students' learning, since they are able to make their own sense of content (Calabrese Barton & Tan, 2009; Rosebery, Ogonowski, DiSchino, & Warren, 2010; Wager, 2012). One struggle that researchers have found in trying to design these productive, hybrid settings is that it is often difficult to make sensible (to researchers, teachers, and students) connections between out-of-school practices and the disciplinary objectives of the classroom (Civil, 2002; Wager, 2012). Additionally, in implementing these learning settings, some have found that students are often reluctant to, or simply do not recruit and deploy these out-of-school resources (Moje et al., 2004).

WSG was designed based on the theoretical view that, through their sustained participation in the mathematics classroom settings, many students have come to understand the world of mathematics and mathematics learning as one that does not include making connections to out-of-school life (Civil, 2002; Holland, Lachicotte, Skinner, Cain, 1998). They interpret mathematics problem solving as an isolated classroom or disciplinary activity with a set of rules determined by other more knowledgeable authorities, and these rules are not always transparent or understandable to them (Boaler & Greeno, 2000; Schoenfeld, 1988). They no longer expect the reasoning they do in school mathematics to have any relationship with the kinds of sense-making they do outside the mathematics classroom. Even when they engage in mathematical activity outside the classroom, students (and their families) often do not view it as mathematics (Goldman & Booker, 2009).

The WSG design took a tack different from previous studies in supporting hybridity by deliberately disrupting existing aspects of classroom mathematics instruction. Instead of designing instruction that bridged students' out-of-school resources with school mathematics learning goals, WSG hoped to invite students to recruit sensible (to them) resources by making unavailable some of those previously imposed on them by school mathematics. The goal of the design was for *productive hybridity* to emerge: the transformed context would contain elements of typical school mathematics and students' own resources, and expand mathematics activity (Engeström & Sannino, 2010) in a manner conducive to the learning of all students.

The WSG tasks asked students to construct geometric figures and explore properties like congruence and similarity outside on a soccer field with ropes, lawn flags, tape, and other materials. The tasks were similar to activities that students had encountered in their typical mathematics instruction, but the physical disruption invited them to see and engage in the mathematics in new ways. By drastically changing the scale of typical classroom geometry, the WSG design disrupted the tools (material and conceptual) and perspective of geometry problem solving. Students no longer had paper, pencils, rulers, protractors, or compasses, and could no longer engage by filling out solutions to problems on, for example, worksheets. Instead, students were asked to reason with and about everyday material objects and their bodies, and find ways to represent and mathematize them on their school soccer field (Figure 1). In working with the geometric objects, students were much smaller in comparison to the figures, and they also had to view them from within, rather than from a birds-eye-view as they did when working at paper and pencil scale. This meant a figure looked significantly different to any individual, and students did not generally have the same view as others.

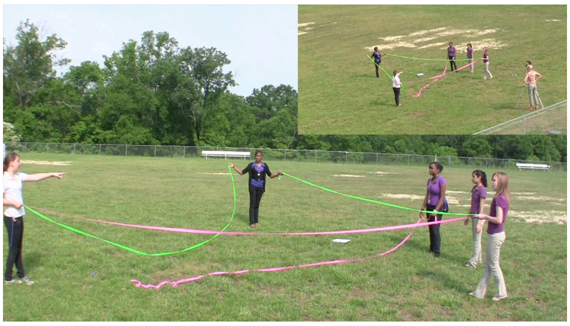

Figure 1. Five students work together to "construct" a WSG rectangle.

The study took place over a five week period in a 7th grade mathematics classroom in an urban public middle school. The lessons were designed by the research team in collaboration with the regular classroom teacher and the school's mathematics coach before and during the five weeks. The lessons were taught by the mathematics coach, in part outside on the school's soccer field, but also in the classroom when the weather prohibited outdoor activity or when the class came back together to discuss what they had done. The research team observed and occasionally acted as teacher's aides, mainly answering students' questions.

Data collected included observations of the class's typical activity before the design study began, as well as dense video, audio, and photographic records of WSG and related classroom activity. We collected student work artifacts as well as interviews with students after the lesson sequence. Ethnographic and microethnographic methods were used in analysis, focusing on how students made sense of the disrupted learning setting, how they negotiated and accomplished problem solving, and what resources were recruited.

In general, students did adapt and invent new tools (both material and representational) and strategies for solving problems. Most strikingly, they developed new inscriptional systems using ropes, lawn flags, and their bodies, and new strategies for constructing congruent and similar triangles and quadrilaterals. They recruited classroom mathematics knowledge as well as knowledge of the everyday materials and their bodies. While analysis could not illuminate *what* out-of-school resources students drew from in order to invent their new ways of constructing, manipulating, and reasoning about the geometric figures, it was clear that their engagements were much more complex than making use of classroom strategies and knowledge transplanted out onto a soccer field and applied at large scale with ropes. For example, one group of students trying to construct and verify that their angles were congruent in their rectangle began developing a tool that would measure the distance between the two sides of the angle at a fixed distance from the vertex.

However, we identified two major dilemmas during the study. One conjecture of the design was that, in the course of their engagements in the disrupted problem solving context, students would develop strategies that might produce the need for additional materials, and that they would nominate some meaningful resources. We found that students were reluctant to request materials to use in the WSG tasks in addition to those we provided initially. Instead, they developed their strategies around the constraints of the provided materials, and modified their strategies when the materials made them problematic. Secondly, as the research team and teachers designed tasks in the midst of the lesson sequence, we found it difficult to maintain or agree on a balance of disruptions and conventional school mathematics that would result in learning that the teachers and their school would value as learning. In disrupting classroom mathematics, we also had to be able to build on the students' engagements in WSG to develop more "recognizable" mathematics knowledge and practices. This issue may be attributed to the imaginations of designers or the skill of teachers, but still raises the question of how disruptive a learning design can be and still be acceptable for school learning? Alternatively, we might ask if it is worthwhile to disrupt what currently counts as acceptable mathematics school learning and objectives in exchange for a comparably rich and applicable set of mathematics practices that are more accessible and meaningful to heterogeneous student populations.

Unbounded Disruptions: How Experiences with Mathematics Exhibits Entangle with School and Everyday Life

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Over the past 15 years, science centers and other informal learning institutions across the U.S. have been developing exhibitions about a wide variety of mathematical topics, including geometry, number, pattern, algebra, calculus, and ratio and proportion (Anderson, 2001; Cooper, 2011). A striking feature of many of these exhibitions is that their design poses a counterpoint to familiar images of school mathematics. For example, at *Design Zone*, a traveling algebra exhibition, visitors will be hard pressed to find references to formal symbolism and syntactic rules. At the traveling exhibition, *Geometry Playground*, visitors pass through a labeled entry advertising an experience with geometry that is "more than what you study in school," then enter an exhibition space free of the axioms and two-column proofs characteristic of high-school geometry. And *Math Moves!* – a permanent exhibition about ratio and proportion that is the focus of this study – conspicuously avoids mention of the cross-multiply algorithm that is the centerpiece of traditional curricular treatments of ratio and proportion. How are visitors to museums and science centers interacting with and making sense of mathematics exhibitions? And, given the apparent contrast between many of these exhibitions and traditional classrooms, how might mathematical learning experiences in museums and schools be related?

While the opportunities for engaging with mathematics in U.S. museums are expanding, to date only a handful of research and evaluation studies have investigated learning in these environments (Anderson, 2001; Cooper, 2011; Guberman, Flexer, Flexer, & Topping, 1999; Gyllenhaal, 2006; Mokros, 2006; Nemirovsky, Kelton, & Rhodehamel, 2012, 2013). Even less is understood about how learning at these exhibitions might relate to past or present participation in school mathematics (Gyllenhaal, 2006). This study explores this unmapped empirical territory by tracing the activities of teachers and students as they move between mathematics classrooms and the exhibition *Math Moves!* in the context of a school field trip.

Math Moves! is a suite of interactive exhibits that invite users to engage multiple perceptual modalities, employ whole-body motion, and jointly collaborate in a variety of open-ended activities broadly related to the mathematics of ratio and proportion (www.mathmoves.org). Museum professionals from four US science centers, as well as educational researchers, including the first author (Kelton), collaboratively designed the exhibition. Copies of the exhibition are now installed at each of the four contributing science centers, with each installation customized to fit the spaces and institutional cultures of the four organizations.

Math Moves! is the outcome of an intentional attempt by the designers to disrupt familiar images of school mathematics along multiple dimensions. Inspired by contemporary theories of embodied mathematical cognition and pedagogy (e.g. Hall & Nemirovsky, 2012), the design of *Math Moves!* stages a purposeful counterpoint to the scales and modalities of perception and movement characteristic of traditional school mathematics through technologies that emphasize wide ranges of both gross and fine motor action, whole-body immersion, and multi-sensoriality. The just-invented technologies of *Math Moves!* also prioritize multi-party collaborative action and open-ended exploration while de-emphasizing symbolic and numeric representation, further serving to disrupt the familiar tools, representations, social organization, and task structures of standard school mathematics.

In addition to the staged disruption of typical school mathematics embedded in the design of *Math Moves!*, school field trips in general are regarded by many as among the most disruptive of educational interventions. Museum professionals and floor facilitators frequently worry that school-group students wildly run "amok" (Parsons & Muhs, 1994, p. 57) as they dart chaotically from exhibit to exhibit. Teachers grapple to smooth over the ruptures field trips cause in the structure of school time while school administrators go to great lengths to address issues of liability related to taking students off campus. Meanwhile, parents rearrange schedules to drop off and retrieve their kids at unusual hours, or to accompany the trip as chaperones. And, although field trip curricula vary widely, students embarking on school excursions to museums and science centers can often expect a day characterized by non-routine activities, less stringent adult supervision, and either different forms of evaluation or the absence of formal assessment altogether. As Nespor (2000) summarizes, "field trips are disruptions in the standard grammar of school practice" (p. 29).

This video-based field study of school field trips to *Math Moves!* complements in-depth analyses of recorded episodes of situated social interaction with a broader ethnographic engagement with the communities under study (vom Lehn, Heath, & Hindmarsh, 2002). Data collection and analysis focus on naturalistic video records of student and teacher behavior in the museum and surrounding classroom activities, and are supplemented with ethnographic techniques of participant observation and informal interviewing.

Project data derive from four classroom field trips to an installation of *Math Moves!* at the Science Museum of Minnesota. Data include extensive video and audio recordings of student and teacher activity in the museum and during surrounding classroom activities, the collection of physical and digital artifacts, contemporaneous and retrospective field notes, and ethnographic interviews with teachers and students. Research participants include two classroom teachers, approximately 80 pre-algebra students from both private and public schools, and 8 parent chaperones. Students represent a range of grade (5^{th} through 7^{th}) and achievement levels, including both gifted students and students identified as having special needs.

Figure 2. A teacher and her students making "real-world connections" with an exhibit called Comparing Frequencies.

Ongoing qualitative analyses of the data in this study resist the common characterization of school field trips as bounded educational interventions that amount to isolated disruptions to the normal school day. Instead, close attention to the activity of students, teachers, and parent chaperones, both on the floor of the museum and in the classroom, reveals several ways in which the seemingly ephemeral experiences at the exhibit face are made to ramify through and entangle with life in school, home, and elsewhere. First, while on the floor of *Math Moves!,* teachers, parents, and students engage in significant interactional work to bring distal scenes, events, and vocabularies from school and everyday life into relation with present events in the museum. These interactions range from relatively explicit and targeted conversations tying specific exhibit features to elements of remembered classroom events, the "real world" (Figure 2), and generic histories of growing and development, on the one hand, to more fleeting and subtle references to pop-culture or participation in extracurricular activities, on the other hand. Second, both on the museum floor and during surrounding classroom preparation and follow-up activities, teachers and students work to temporally situate experiences in *Math Moves!* into longer trajectories of school mathematics and science curriculum. This includes relatively brief conversations that allude to past or future topics or problems in school math and science as well as, in the case of one of the participating schools, more in-depth rearrangement of curricular schedules in order to embed the field trip in a related school mathematics unit. Finally, analyses of data from one of the participating schools reveals how elements of the embodied pedagogical philosophy undergirding the design of *Math Moves!* subtly infiltrated into the ways in which teachers and students engaged in school mathematics during the days surrounding the trip (Figure 3).

Figure 3. Classroom preparation activity (in the same class as Figure 1) that imported the explicit focus on whole-body motion and multi-party collaboration in *Math Moves!* into the space of the classroom.

Ongoing analyses also explore how felt contrasts between school and museum mathematics provided occasions for teachers and students to confront and assess different models for what it means to learn and do mathematics. Sometimes teachers and students navigated these differences by positioning the mathematical practices implicated in the design of *Math Moves!* as more fun and memorable routes to the same disciplinary content taught in school. At other times, students mobilized schooled models of mathematical activity in order to openly question whether *Math Moves!* should count as mathematics at all. Similar to the challenges Ma (2014, this symposium) confronted in working to disrupt classroom practice through WSG while still rendering the mathematics recognizable, the ambivalent dynamics with which participants in this study varyingly did and did not regard their own activities with *Math Moves!* as genuinely mathematical raise important questions about the relationship between the disruptive agendas of museum mathematics exhibitions and the goal of engaging learners in activities they are able to acknowledge and value as mathematics.

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