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Mathematical Dispositions at an Art Crating Company

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An individual's *mathematical dispositions*, or "ideas about, values of, and ways of participating with" (Gresalfi & Cobb, 2006, p. 50) the discipline has been identified as an important dimension of mathematics learning (e.g., Cuoco, Goldenberg, & Mark, 1996; Gresalfi & Cobb, 2006; National Council of Teachers of Mathematics, 1989; National Research Council, 2001; Schoenfeld, 1983; Thompson, Phillip, Thompson, & Boyd, 1994). The *Curriculum and Evaluation Standards for School Mathematics* published by the National Council of Teachers of Mathematics (NTCM; 1989) listed "Mathematical Dispositions" as an evaluation standard, or an indicator of successful instruction. In the National Research Council's (NRC; 2001) influential report, *Adding It Up: Helping Children Learn Mathematics*, mathematical proficiency was defined as an intertwined combination of five different strands: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. All five strands mutually influence each other, and disposition is as central to and integral a part of knowing, doing, and learning mathematics as the other four: "A productive disposition develops when the other strands do and helps each of them develop (p. 131). A productive disposition is not just an important *goal* for mathematics learning, but also *supports* other strands of mathematics learning as it develops. For example, a student who sees mathematics as a domain that one can reason about might solve a problem trying to organize and make use of relationships between quantities, while another who sees mathematics as a disjointed set of rules put forth by a textbook might simply look for a recently-learned procedure that seems to fit the given information, and give up when one does not readily present itself. We might say that this first student has a conceptual orientation toward mathematics and learning, while the second has a calculational orientation (Thompson et al., 1994). These orientations, or dispositions, have consequences for how they engage in mathematics, and in learning activity. The NRC report would argue that the second, more calculationally or procedurally driven disposition, is not productive for learning.

Mathematics education researchers have begun to develop ideas about what does count as a productive disposition. For example, few would argue that a conceptual orientation is ideal for developing deep mathematical understandings. In *Curriculum and Evaluation Standards for School Mathematics* published by the National Council of Teachers of Mathematics (1989), it was suggested that productive dispositions can be detected "in the way students approach tasks—whether with confidence, willingness to explore alternatives, perseverance, and interest—and in their tendency to reflect on their own thinking" (NCTM, 1989, p. 233). Later, the NRC report (2001) listed "the tendency to see sense in mathematics, to perceive it as both useful and worthwhile, to believe that steady effort in learning mathematics pays off, and to see oneself as an effective learner and doer of mathematics (p. 131) as features of a productive disposition. Many of these overlap (confidence and seeing oneself as an effective learning and doer; interest and perceptions of mathematics as useful and worthwhile; perseverance and a belief that steady effort pays off), and they have persisted as elements of the *Common Core State Standards for Mathematical Practices* (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010), such as to "Make sense of problems and persevere in solving them" (CCSS.MATH.PRACTICE.MP1) and "Look for and make use of structure" (CCSS.MATH.PRACTICE.MP7).

However, the concept of mathematical disposition still remains underdeveloped. Gainsburg (2007) argued that conceptions of mathematical dispositions cannot be said to come from research on mathematicians, given the lack of empirical studies on the issue. Further, what relationship does (or will) a disposition for learning mathematics have with a mathematical disposition? What counts as a positive or productive mathematical disposition (as opposed to a negative, or unproductive one)? Can a disposition be productive in one circumstance, yet unproductive in another? What kinds of mathematical dispositions might still result in successful mathematical engagements? What different dispositions are important for different kinds of mathematical activity?

Gainsburg's (2007) study of structural engineers made strides in teasing these questions out and in addressing them. Through a grounded analysis of the practices of structural engineers, characterized a new form of mathematical disposition, that of "skeptical reverence—mathematics is a powerful and necessary tool that must be used judiciously and skeptically" (p. 498). She argued that this disposition is important for the students' future uses of mathematics, given real world contexts with features that often influence, interrupt, or override mathematical activity and results.

Following Gainsburg's (2007) reasoning, we investigated employees at an art crating company we call CratEx, that specialized in designing and building custom crates for art objects. Like Gainsburg's structural engineering firms, CratEx employees viewed their work as highly consequential—mistakes could lead to the damage or destruction of artifacts of significant cultural and monetary value. Additionally, it was clear to us that mathematics was heavily used and relied on at CratEx. However, there was no assumption or requirement that employees were able to do complex mathematics there. In fact, the majority of employees we talked to described themselves as failures in school mathematics, and they did not recognize much of their work as "mathematical." While they acknowledged some basic mathematics in their work activity (ruler-based measurement, arithmetic), our observations and analysis revealed much more complicated spatial reasoning and representation. How is it that a group of individuals, all vociferously committed to being "bad at" mathematics, could do so much of it, so successfully, on a daily basis? We reasoned that, if we could learn more about the art craters' mathematical engagements, we might derive some insights into supporting the success of others with similar dispositions toward mathematics in other settings. This paper reports on the ethnographic case study conducted at CratEx. In particular, we focus on the mathematical dispositions of one long-time employee of the company, and consider how his case might serve to address some of the questions above.

Theoretical Framing

In their *Curriculum and Evaluation Standards* report, the NCTM (1989) explained that "disposition refers not simply to attitudes but to a tendency to think and to act in positive ways" (p. 233). In other words, they suggested we look to regularities in learners' mathematical engagements to gauge the kinds of dispositions they are developing. This is sensible advice for evaluating instruction, the topic of the document, but also as an analytic strategy for teasing out a concept still under development, as is the goal here. To do this, we take up sociocultural accounts of learning, which view learning as shifting patterns of participation in a set of practices, often associated with some community (Lave & Wenger, 1991). This takes into consideration local conditions of activity, including learners' goal-driven actions, social relationships and interactions, developing identities within activity, and how they all influence each other.

The sociocultural perspective highlights the diverse forms that mathematical activity may take within different "everyday" contexts (e.g., Lave, 1988), Stevens (2013) argued that:

> everyday math studies show quite clearly that the forms and functions of 'mathematical' activity—or whatever we call what people do with number, calculation, geometricized shapes, predictive projection, and quantitative inference—don't often directly resemble those of school math. Mathematical practices are embodied in expressive forms and bodily modalities, distributed to other people and technologies, and are embedded in the language of the locals. (p. 75)

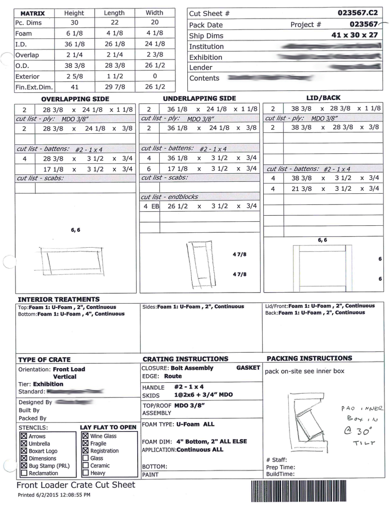
These mathematical practices, in turn, support particular practice-linked mathematical dispositions. Gainsburg's (2007) skeptical reverence, for example, emerged through the study of activity where mathematics was used for the accomplishment of structural engineering tasks. I follow Gainsburg in assuming that mathematical dispositions are tied "more closely to settings than to individuals. No one is solely a shopper or engineer or dieter or student—one can be all of these things and more, and my presumption is that an individual's view of the role of mathematics varies with respect to settings" (p. 480). The analysis of mathematical dispositions at the art crating company that follows is driven by the assumption that both mathematical practices and dispositions are tied to contexts of activity.

CratEx

CratEx is a highly regarded art crating company in the United States. They are known for reliably designing and building high quality crates for art objects for safe transport. For example, one museum might want to borrow several items from another for a special exhibition. Those items would need to be packed and safely transported for the exhibit, then repacked and sent home after it was over. A CratEx project manager would examine the items, either on-site or using information sent by the client, then design one or more crates, depending on the size, shape, and material make-up of each object. He or she would then fill out a form called a "cut sheet" (Figure 1, left) for each crate that included several configurations of relevant dimensions and other information. Sometimes another form with "packing information" (Figure 1, right) is also filled out, to include additional details on interior configurations of packing materials and how the objects will fit inside. The cut sheet, packing information, and at times the project manager were the primary source of information for workers in the crate shop to cut and assemble the exterior of the crate, and for those in the packing department to make and fit the interior with supportive materials.

The CratEx employee who is the focus of this paper is a project manager named Drew, also Assistant Director at the company. He had been at the company 14 years, and before that had worked as an art handler, then manager of art handlers at a museum. In an interview he reported that he hated math growing up, and that he had failed algebra in the ninth grade. Now, he said, he was "fine" with "the numbers, day to day…it's not that difficult, the adding and subtracting."

The “spatial relationships,” though, were easy for him. “Which is why I guess I went into art,” he told us, “cause it wasn’t numbers.”



MATRIX	Height	Length	Width
Pc. Dims	30	22	20
Foam	6 1/8	4 1/8	4 1/8
I.D.	36 1/8	26 1/8	24 1/8
Overlap	2 1/4	2 1/4	2 3/8
O.D.	38 3/8	28 3/8	26 1/2
Exterior	2 5/8	1 1/2	0
Fin.Ext.Dim.	41	29 7/8	26 1/2

Cut Sheet # 023567.C2
Pack Date Project # 023567
Ship Dims 41 x 30 x 27
Institution
Exhibition
Lender
Contents

OVERLAPPING SIDE	UNDERLAPPING SIDE	LID/BACK
2 28 3/8 x 24 1/8 x 1 1/8	2 36 1/8 x 24 1/8 x 1 1/8	2 38 3/8 x 28 3/8 x 1 1/8
cut list - ply: MDO 3/8″	*cut list - ply: MDO 3/8″*	*cut list - ply: MDO 3/8″*
2 28 3/8 x 24 1/8 x 3/8	2 36 1/8 x 24 1/8 x 3/8	2 38 3/8 x 28 3/8 x 3/8
cut list - battens: #2 - 1 x 4	*cut list - battens: #2 - 1 x 4*	*cut list - battens: #2 - 1 x 4*
4 28 3/8 x 3 1/2 x 3/4	4 36 1/8 x 3 1/2 x 3/4	4 38 3/8 x 3 1/2 x 3/4
17 1/8 x 3 1/2 x 3/4	6 17 1/8 x 3 1/2 x 3/4	4 21 3/8 x 3 1/2 x 3/4
cut list - scabs:	*cut list - scabs:*	
	cut list - endblocks	
	4 EB 26 1/2 x 3 1/2 x 3/4	
6, 6	4 7/8 4 7/8	6, 6 6 6

INTERIOR TREATMENTS

Top: Foam 1: U-Foam , 2", Continuous
Bottom: Foam 1: U-Foam , 4", Continuous
Sides: Foam 1: U-Foam , 2", Continuous
Lid/Front: Foam 1: U-Foam , 2", Continuous
Back: Foam 1: U-Foam , 2", Continuous

TYPE OF CRATE

Orientation: Front Load Vertical
Tier: Exhibition
Standard:
Designed By
Built By
Packed By

STENCILS: ☒ Arrows ☒ Umbrella ☒ Boxart Logo ☒ Dimensions ☒ Bug Stamp (PRL) ☐ Reclamation

LAY FLAT TO OPEN: ☒ Wine Glass ☒ Fragile ☒ Registration ☐ Glass ☐ Ceramic ☐ Heavy

CRATING INSTRUCTIONS

CLOSURE: Bolt Assembly GASKET
EDGE: Route
HANDLE #2 - 1 x 4
SKIDS 1@2x6 + 3/4″ MDO
TOP/ROOF ASSEMBLY MDO 3/8″
FOAM TYPE: U-Foam ALL
FOAM DIM: 4" Bottom, 2" ALL ELSE
APPLICATION: Continuous ALL
BOTTOM:
PAINT

PACKING INSTRUCTIONS

pack on-site see inner box
PAD INNER BOX IN @ 30° TILT
Staff:
Prep Time:
BuildTime:

Front Loader Crate Cut Sheet
Printed 6/2/2015 12:08:55 PM

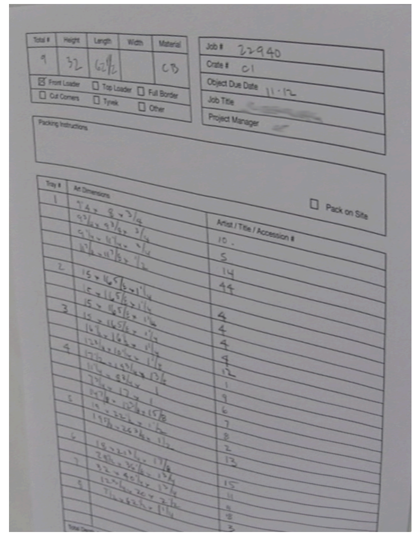


Figure 1. Examples of a cut sheet (left) and packing information (right).

Drew’s described his work responsibilities at CratEx as interacting with clients, determining what they need, and making sure they get it from beginning to end. His day-to-day tasks included seeing artwork, measuring it, making recommendations for how it might be crated, generating work orders for the other departments at CratEx for building the crate and preparing the interiors, and handling logistics for trucking and other involved parties. From these interrelated tasks emerged a network of concerns that shaped the trajectory of each project in different, nuanced ways. It is against this backdrop that Drew engaged in his crate design activity, and related mathematical practices.

Data and Methods

Our work is guided by the question, “What were the mathematical dispositions of workers at CratEx?” For this paper in particular, we focus on Drew’s mathematical dispositions in the context of his crate design activity. Before we describe the data and methods for the study, it is necessary to first attend to a dilemma we faced, given our theoretical framing. Recall that the majority of our participants, including Drew, reported being “bad at” mathematics, having failed high school courses, and/or discontinuing formal study as soon as it was allowed. At the same time, we saw them engage in various forms of what, to us, was sophisticated mathematical reasoning. This led to a dilemma; “bad at it” didn’t necessarily seem like their mathematical disposition in their work setting, but rather their disposition toward school mathematics. While we were committed to honoring an endogenous perspective on their activity (Stevens, 2010), and building our characterizations of mathematical dispositions on members’ perspectives, we felt it was also important to develop an understanding of their engagements in activity that fit broader definitions of mathematics, just as researchers have done in prior studies of everyday mathematics (mentioned above). That included their dispositions toward it, even if they didn’t see the mathematical activity as an “it,” or a coherent category that they named or talked about. Therefore, in order to analyze the mathematical dispositions of CratEx employees, we needed a clear articulation of what we, as analysts, saw as "mathematical." We used a broad definition to capture activity (and categories) that might be found in art crating but not necessarily in academic mathematics. We treated any activity that involved reasoning with quantitative or spatial relationships as mathematical (from here on, the terms "mathematics" and "mathematical dispositions" will refer to mathematics as we define it).

Research design used primarily ethnographic methods (Spradley, 1980), including participant observation and interviews. Data included field notes, video recordings, and artifacts collected over an eight-month period. As the study progressed and mathematical practices were defined and characterized, fieldwork shifted to selective observations directly targeting those practices, and we began constructing grounded categories (Charmaz, 2006) for mathematical dispositions. Interviews focused on workers' histories of participation in (formal, school) mathematics, and the company. Video served as data for microethnographic analysis (Streeck, & Mehus, 2005) of work and mathematical practices, providing insight into how mathematics is socially constructed, from the workers' perspective. The frequent collaborative consulting interactions that took place made mathematical practices visible for analysis. These interactions also allowed for analysis of how workers positioned themselves and each other in relation to mathematical activity. Analysis addressing Drew's mathematical dispositions was informed by analysis of the corpus in general.

Results

In what follows we describe two mathematical dispositions that emerged in our analysis of Drew's work. These mathematical dispositions extend the NRC's (2001) description of seeing mathematics as "useful and worthwhile" to an orientation to mathematical strategies and solutions *in use*, accountable to the organization of work and material conditions. We describe how they are sensibly situated in the work of CratEx, and provide brief examples of data that demonstrate what this means in relation to Drew's work activity. The examples are not meant to be representative of typical activity, but rather illustrations of how the dispositions play out in practice.

Early in our ethnographic inquiry into spatial practices at CratEx, we noted how collaborative all work activity was. By collaborative, we mean two things. First, each project (and the associated art objects) involved a trajectory from client to project manager to the different specialized departments responsible for different aspects of the crate to transport to final destination. At any given moment in the project, what came prior and work yet to be completed was salient for those involved. Second, work was also collaboratively undertaken in the moment. For example, very large or complicated crates might be worked on in teams; or someone might come lend a hand when they have a free moment; or some processes, like aligning a long piece of foam, might need two or more people. When questions arose, it was commonplace for employees to seek the help of others in their department, or to consult with the project manager. We have come to think of the distribution of tasks along two dimensions of work, one temporal and one sociomaterial.

As a project manager, Drew's involvement spanned the full trajectory of the project, beginning with initial contact with the client through until crates were shipped. This trajectory and all the individuals and groups involved were consistently salient to him as he designed crates. One consequence of this was that, in his mathematical practices, where quantitative and spatial information came from and how it was to be used was constantly under scrutiny. Mathematics in use meant that Drew's disposition toward mathematical solutions positioned them as the product of and products for dynamic and ongoing human activity. This might be contrasted with typical school mathematics solutions, which tend to mark the completion of a task or problem once discovered. They are treated as durable "answers" that can be scored as right or wrong (or eligible for partial credit), and once answers are found, problems are treated as "solved." We often hope that they may generate additional questions (e.g., Driscoll's 2007 Geometric Habit of Mind, "balancing exploration and reflection"). In contrast, Drew treated solutions as practical outcomes of goal-directed work, with specific relations to his own or others' work. Drew explained that information that came with art objects might have been acquired for a variety of purposes, and therefore subject to different definitions or standards of precision. One afternoon, while he measured a set of rectangular framed pieces, he noticed that the second of a diptych (a pair of separate pictures displayed or even hinged together), was not the same size as the first he had measured. Consulting his inventory list, which contained names, measurements, and thumbnail images of each piece, he told us, "Yeah. In this case these are a diptych but they ARE different sizes. Even though the picture looks like they are the SAME size. So. You always measure. Everything."

As the creator and provider of spatial information and representations, he was also attentive to future uses of his work. In talk, his problem solving decisions were often blended with the work that would result from his solutions. His treatment of the measurements and spatial relations were, in a sense, transparent (Roth, 2004) to the subsequent work that relied on the representations he produced. On the same afternoon he discovered the mismatched diptych pieces, he explained to us how he was designing a crate that would hold multiple rectangular pieces. The crate would hold multiple trays, and each tray would hold multiple paintings side-by-side. He used his inventory list to help him choose pieces he would place on each tray, based on a system of ascending depths. As he filled in the information for the third tray (see Figure 1, right), he commented, "So, I don't have anything else that's one and a quarter so I'll just go with a smaller piece. They'll just build up behind the piece so it's all flush on the front." So far he had listed two pieces of one and a quarter inch depth on that tray, but there were no more in the inventory with that depth. However, there was still room on the tray, and for efficiency's sake Drew wanted to use that space. So he chose a smaller piece with less depth, justifying to us how this would be handled by the packing department. His design decision here anticipated plausible design decisions by others downstream.

The sociomaterial distribution of work at CratEx involved not only a broad yet dynamic division of labor, but an accountability to the material conditions of needing to build and outfit a crate in order to pack and safely transport art objects. To this end, work at CratEx began as closely to the material realities as possible, and was continually grounded in the materials, even as multiple representations circulated and guided problem-solving and decision-making. These materials included the art objects themselves as well as the wood, foam, and other elements that would make up a finished crate and the equipment needed for construction, including workers' bodies. Even though CratEx employees often referred to "rules," "standards," or "established procedures," they made clear that these were not routine. The particulars of the project led all activity. If any standards applied, they could be put to use. Often they did not, and workers made decisions and solved emergent problems based on elements of past or ongoing work work. When asked if he feels his is still learning in his job, Drew explained that "There's always something coming across your desk that you haven't dealt with before, in terms of an object, in terms of size or weight or materials that it's made of, or things like that." He gave an example of a recent encounter with a taxidermied owl:

> I had to do a taxidermied owl? Uh, which I've never, you know. And it had its wings spread out. So, it's like, and it was hanging from the ceiling so there's no mount, so it's just this- stuffed OWL and I, you know and you measure it hanging on the ceiling and I didn't actually get it into my hands until I had the crate in front of it you know, and um, It's like, where do yo:ou, touch an owl? Because, it's, you know, there's- the wings are out, so you can't you know, all the wing's behind it you can't touch. You can touch like, the shoulders, and the chest and the back. And and, but, it's still FEAthers. So you can't- put- anything too HARD against it or you're gonna::a, squish the feathers or ruffle the feathers and, and, I- you know.

Drew's description highlights the many considerations that may feature in the design of a crate, including the shape of the object ("it had its wings spread out"), the materials that comprise the object ("but, it's still FEAthers….you're gonna::a, squish the feathers or ruffle the feathers"), and the configuration of delicate parts of an object in relation to parts that can hold up to stabilizing and supportive components of a crate ("where do yo:ou touch an owl?"). Rather than, for example, beginning with a model or a standard that approximated his needs, then adjusting it to the particularities of the problem, the details of the project shaped Drew's decisions for how to shape and place supports to prevent the owl from rotating or shifting in any direction during transport. This is akin to a "brute-force" disposition toward mathematical problem solving, grounded in specifics, somewhat counter to practices related to generalization and abstraction valued among many mathematicians and in the Common Core State Standards.

Discussion

We have described two mathematical dispositions that are readily observable in Drew's work in designing crates at CratEx. The first is a treatment of mathematical findings as conditional and situated in a stream of work, rather than durable solutions to generally meaningful problems. The second is a brute-force orientation toward problem solving, one that uses standards and established procedures as tools for filling in details rather than broad models that initiate solutions, to be refined based on the details of the project. Given their shared work goal of keeping art objects safe and a shared accountability to the organization of work at CratEx, we anticipate that further analysis will reveal that workers in other departments of CratEx display similar forms of mathematical dispositions, but with nuances, given their varying responsibilities, expertise, and positioning in the work.

These findings highlight the situated nature of mathematical practices, already elucidated by many everyday mathematics studies, as noted above. Building on Gainsburg's (2007) work, they also serve to tease out how the particular contexts of mathematical practices shape the kinds of mathematical activity that is valued and how participants orient toward that activity. In both of these settings, Stevens (2013) might point out, mathematics features *in* activity, rather than *as* activity (as it is in school mathematics learning or for professional academic mathematicians). However, while Gainsburg's study was situated in a setting where formal academic mathematics was perceived as important, this study investigated a place where most participants reported dislike of and failures in formal mathematics. This study of mathematics occurred in a setting that was neither a mathematics classroom, nor "professional" mathematics, nor a profession that explicitly uses mathematics. The dispositions discussed in this paper point to a possible disconnect between the mathematical dispositions we see in Drew's crate design activity and those valued in school mathematics. We wonder, if these dispositions for mathematics were to be fostered, what kinds of mathematical activity might be valued? What kinds of learning might be possible? Who might have access to it? While these are still open questions, we hope that more expansive understandings of possible dispositions toward (doing) mathematics may lead to new, more equitable possibilities for mathematics learning.

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