This is the accepted manuscript version of the chapter: Wilkerson, M. H. & Gravel, B. E. (2020). Storytelling as a support for collective constructionist activity. In N. Holbert, M Berland, & Y. Kafai (Eds.) *Designing Constructionist Futures: The Art, Theory, and Practice of Learning Designs.* Cambridge, MA: MIT Press.

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Storytelling as a Support for Collective Constructionist Activity

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As new forms of expressive technologies emerge, so too do new ways for learners to build constructionist artifacts and related knowledge (Papert, 1980). But while personal meaning making is important, participationist (Kafai, 2016) and literacy-based (DiSessa, 2001) perspectives highlight that cultural status, expression, and community undergird the power of constructionism. Making and programming are central practices in constructionism in no small part because of the relative shareability and modularity of the artifacts they produce. Digital and physical constructions can be connected together, remixed, and built upon one another to create more complex ones. Thus, an important part of teaching in the constructionist paradigm is to position student-generated artifacts, which often bear different personal meanings and perspectives, as contributions that, in combination, can help accomplish collective goals.

Decades of research in education have explored how teachers can foster communities of learners that build knowledge together (Brown & Campione, 1994), including by specifically encouraging learners to engage in meaning-making by interrogating diverse, even contradictory perspectives (Rosebery, Ogonowski, DiSchino, & Warren, 2010). Within the constructionist community, studies have explored how students' ideas and code, made public through construction and sharing, can become resources for their peers (see the case of Debbie and Sherifa for just one example; Harel & Papert, 1990). More recently, constructionist designs to

support sharing such as the Scratch-R online community or the NetLogo Modeling Commons allow learners' constructions to be accessed globally and "remixed" by others who modify, appropriate, or build upon the computer code that generates a given program.

There are still a number of open questions, however, about how the collaborative nature of constructionism can be best enacted in classroom settings. "Remixing," as it is currently conceptualized and researched, emphasizes collaboration among affinity-based communities in which students often work asynchronously, and in ways primarily driven by individual goals or interests (Hill & Monroy-Hernández, 2013). But in classrooms, students are often expected to collaborate synchronously on tightly focused projects that align with core concepts as determined by the classroom collective, curricula, or state standards. Indeed, we find that classroom teachers are often concerned that constructionist activities may lead to the generation of divergent artifacts and conclusions, rather than to consensus and shared understanding.

In this paper, we explore storytelling as a conceptual tool that teachers and facilitators can leverage to bring together learners' artifacts in ways that support collective progress and synthesis in constructionist activity. We argue that explicitly leveraging a storytelling lens (Ochs, Taylor, Rudolph, & Smith, 1992; Bal, 1997) highlights the potentially generative role of (1) perspective, (2) material, and (3) problem solving for organizing student construction and synthesis around a collective conceptual theme. To illustrate, we describe two projects that engage learners in solving locally relevant problems through digital fabrication and making and data analysis and visualization construction, respectively. First, we more deeply explore theories of narrative and storytelling to illustrate what they can add to conceptualizations of collaborative constructionist activity in a classroom context.

What a Storytelling Framework Adds to Collaborative Constructionist Activity

Narrative is often cited as an overarching cognitive and communicative structure that helps humans organize their experiences. By most accounts, narrative temporally organizes the

retelling of critical events that happen to some protagonist in order to present a resolution to some problem or inconsistency. While several such theories of narrative have been leveraged in the educational research literature, in this chapter we draw from two in particular that emphasize its more social and collaborative features; these are Bal's (1997) narratology and Ochs' and colleagues' (1992) notion of storytelling as theory-building activity.

Bal (1997) emphasizes that analysts should attend not to what is or is not a narrative, but rather on how storytelling and shared understandings are accomplished through the construction and consumption of artifacts. She proposes that narratives comprise multiple stories and texts written and shared within a given community. Each story is told from a specific perspective and offers an incomplete pathway through the underlying narrative system. Each text is a particular (written, visual, filmic, or other) artifact that communicates and edifies a given story. The stories, as collections, reflect shared cultural constructs that provide insight into the actors and relations that make up the underlying narrative system. A narrative is built through different artifacts that communicate those stories, and the modality/materiality of these artifacts (text, visual, spoken word) can dramatically affect what aspects of the story are emphasized. In this way, the narrative becomes a shared, multiperspectival construction that is preserved in artifacts and reflects the values and customs of the community that produced it.

Like Bal, Ochs' and colleagues' (1992) treatment of narrative focuses on its co-constructed, perspectival, and cultural nature. But whereas Bal focuses on how narratives are edified through a diversity of stories and artifacts, Ochs and colleagues describe how narratives can be co-constructed and revised in the moment verbally, by multiple interlocutors with different perspectives on the same event. Here, as in Bal's account, different perspectives may be presented as stories that together, and in interaction, make up a narrative. With a focus on synchronous co-narration, Ochs and colleagues highlight that narratives can also explain and solve problems in this way. The act of co-narrating provides people with different perspectives to iteratively correct and enrich one another's accounts of often surprising or unexpected events. This, in turn, offers opportunities to engage in complex causal reasoning and problem solving—in which an anomalous event is understood and possibly resolved through multivoiced storytelling and repair.

Drawing from Bal and Ochs' accounts of narrative highlights three major points that are especially important for collaborative work. These are that: (1) narratives are composed of multiple perspectives, (2) the layering of these perspectives allows narratives to offer complex explanations and problem solutions, and (3) that narratives can be preserved and shared through the construction of multimodal artifacts. We see a number of parallels between these features of narrative as a collective enterprise, and commitments underlying constructionist activity:

Perspective. An oft-cited benefit of constructionism is that learners are able to generate and share different solutions, procedures, or perspectives on problems (Abrahamson, Berland, Shapiro, Unterman, & Wilensky, 2006; Harel & Papert, 1990). When put in conversation with one another, these stories highlight invariances in disciplines while also bringing multiple epistemologies into contact with each other. The stories encourage reflection on different ways of thinking, allowing the learner to observe points of connection and difference between aspects of a domain.

Materiality. Constructionism's emphasis on the production of physical and digital artifacts draws attention to material in construction and learning. Indeed, constructionist activities often make use of specialized toolkits (Blikstein, 2015) intended to highlight particular construction principles, practices, or disciplinary concepts. As people imagine, create, and refine objects in the world, they are expected to enter into a reflective conversation with these objects, learning from the ways they interact with and engage them.

Problem Solving and Explanation. Finally, a major focus of constructionist theory is that it allows for explication, connection, and debugging (Papert, 1996) of the

building blocks and relationships that underlie complex events, products, or problems. In this way, constructionist environments, through materials and representations, are expected to serve as sources of feedback in themselves—encouraging the learner to identify and repair misunderstandings, solve problems, and develop explanations of complex events.

Exploring Collaborative Constructionist Activities through a Storytelling Lens

Below, we present two examples of activities in which collaborative stories—and their perspectival, material, and problem-solving nature—play a central role. Both focus on investigating core scientific phenomena, energy transfer, and earth systems, respectively. Both also used storytelling as a design support to organize how learners engaged in, and reflected on, collaborative constructionist activity. In the first example, participants were in-service educators enrolled in a summer workshop focused on introducing digital data analysis and visualization to middle-school science classrooms. That case leveraged the structure of collaborative storytelling, with participants each focusing on different parts of an investigation and later assembling their findings to make inferences about the same shared world. In the second, participants were students in a design and engineering class housed in a large makerspace at a public comprehensive high school. In this case, collaborative storytelling served as a tool for two focal students to reflect on their learning after the activity and highlight ways in which their own contributions were positioned relative to, and informed by, the work of the rest of the class.

Yellowstone Cascades

Our first example is drawn from a professional development workshop for middle-school educators. The workshop focused on the use of storytelling approaches to introduce students to data analysis and visualization, especially student construction of data visualizations, in science

instruction. During the second day of the workshop, participants completed an activity that involved analyzing a large, multiparameter dataset to address a driving prompt. The prompt was: "In 1995, grey wolves were reintroduced to Yellowstone National Park after nearly 70 years of absence. In the decades since there have been a number of changes within the park ecosystem, including that the rivers have gradually changed their course to form a more meandering pathway. Can this be explained by the reintroduction of just a single species? If so, how? If not, what happened?"

The story of Yellowstone wolves is well known. Most accounts assert that the paths of rivers changed through a trophic cascade, whereby wolves reduced the elk population, thus increasing the amount and size of vegetation around the river, allowing beavers to build dams in some places and stabilizing the riverbanks in others. About half of the participants in the workshop were aware of this popularized version of events. However, it has been challenged within the scientific community, and factors such as weather and human impact have also been implicated. We provided participants with a large data set about animal populations, vegetation, weather and precipitation, and other key factors. We asked them to use digital analysis tools and any other representational conventions they saw fit (e.g., pictures, graphs, flow charts) to create a visual explanation for the changing rivers and their potential relationship to wolf reintroduction, using the data as evidence.

Below, we share excerpts from one participant group's work and reflections on this project as they created a narrative to explain the potential relationship between wolves and rivers in Yellowstone. We focus on this group because they began by presenting a number of hypotheses for the change in rivers, some related to wolves and others not. These hypotheses, and participants' various areas of expertise, let different subgroups explore different aspects of the data set—coming together at the end of the activity to create a collective story artifact that was then populated by various findings and material representations created by different actors in the group.

"Does anyone think that immediately it's definitely wolves?" At the beginning of the activity, the group began by brainstorming possible explanations for the change in river paths.

They were provided with a series of four photographs of the same riverbed taken in 1924, 1949, 1961, and 2003 to ground their discussion. Many participants posited mechanisms for the change to the ecosystem, often drawing from perspectives and experiences outside of the workshop or details others did not notice in shared resources. While these began focused on the impact of wolves, they quickly expanded to include a number of factors.

Daryn: I would only go so far as to say that there's some animal or plant that's prey to a different animal that is now hunted by the wolves.

Anabel: I see in these pictures those rivers changing at several points, so there must be something upstream that maybe humans are doing.
Ted: There was a huge fire in Yellowstone. Like in 94, 95.
Phil: Where there's not wolves, in 1949 and 61, there's less vegetation, so maybe there's erosion factors, or the elk walking across or eating and then in 2003, 1924 where there had been wolves, there's the same vegetation buildup along the riverbank.

Perspective, then, in this case led the group to consider a variety of potential causes very early in the activity. These perspectives then led the group to identify specific areas of expertise or interest for which participants then became responsible. The group broke the problem into smaller sub-areas to be explored (animal population trends, vegetation trends, climate/weather), making it more tractable and allowing for more in-depth exploration.

"You looked at just animals." When coming back together after conducting investigations on various categories, different pairs within the large group reported their findings and revisited whether they supported any of the many theories posited at the beginning of the activity.

Ben: Yea, we were hoping to learn just mammals, not what was happening with the whole thing, we were just hoping to understand which animals where the ones to pay attention to for our part.

Marisa: But it wasn't like, you were, you saying okay, I need to look at conifers and beavers so I can make this connection.
Ben: No.
Marisa: Okay. So we divided it by, we were looking for trends even before we starting to look for, we were looking for trends within categories or groups.
Ben: Yea. But the goal was always to eventually track those back.

Because the pair focused on their own subset of the investigation, they had to work together to develop a skeletal flowchart of causal events (figure 19.1a). This skeleton then provided an infrastructure to link each group's claims and findings (figure 19.1b).

{~?~IM: insert Figure 19.1.}

Figure 19.1

The group's skeletal theory of causation (left, recreated) was populated by explanations from different members of the group (center), then linked to specific findings from data (right).

"Are there any areas that feel really iffy to you?" Upon inspecting the flowchart, one member of the group explicitly asked peers if they felt unsure about any connections articulated within. This led several members of the group to question the last link, between beavers and the changes to rivers. One participant proposed groups add specific evidence in the form of data or relationships for each connection on to the shared poster (see above).

Yoel: [gestures to Beavers connection on flowchart]

Ted: Yea, this feels kind of loose to me.
Marisa: Could it be something, like the elk trampling it [vegetation near the river]?
Yoel: I didn't feel like there was a lot of evidence for this.
Marisa: I mean, we saw a reduction in I think they called it browsing.
Yoel: Yea.
Phil: It went from 100% down to 20. So, uh, should we include our empirical data?

Ted's final re-problematization of links in the group's final explanation led subgroups to revisit their data, explain it in more detail to their peers, and in some cases conduct new analyses better suited to the group's overall narrative. In this way, the shared product, as a text of the narrative the group had created, introduced, externalized, and offered infrastructure for the group to solve new problems made evident within aggregated work.

Bus Stop 2.0

Creative Design and Engineering is an experimental course taught in a making space, designed specifically for high-school students from nondominant communities. Together with the teacher, Ms. Freewoman, researchers co-designed the course to introduce students to engineering inquiry,

design, and making, through problems they identified in their communities. For the culminating activity after a semester of developing facility with tools and approaches to engineering and design, students were asked about “pressure points” in their lives—places where life could be more equitable or hospitable.

The class converged on the issue of the public bus stop—“They’re cold, there’s no place to charge your phone, and they smell like pee.” Collectively, the class scoped this large problem by identifying specific features of an improved, “fancier” bus stop that they wanted to design and build. This project happened in late winter in New England and Luis and Taddeo, with memories of winter storms and cold temperatures fresh in their minds, chose the problem of heating the bus stop. They searched online for radiant floor heating systems; found them to be complicated, expensive, and described using technical language intended for contractors. Luis and Taddeo were motivated by their idea, but they were stalled in their process.

To provide Luis and Taddeo with footholds into this design problem, the researchers and teacher presented two interventions. The students were encouraged to design a wooden platform using a computer numerical control (CNC) mill, to explore the configuration of underground tubing needed for heating. They were also introduced to low-cost material resources such as “heat tape” that could be used to explore possible heating solutions, and the scientific and engineering principles that underlie them, in the context of the prototype platform. These designed interventions led Taddeo and Luis to begin constructing problem solutions across a variety of material forms. They sketched ideas, borrowed images from Google, manipulated those images to become design files in Easel, and eventually fabricated their prototype using the mill (figure 19.2). At the same time, the story of their design evolved and became interwoven with the materials through the activities they were encouraged to try.

{~?~IM: insert Figure 19.2 here.}

Figure 19.2

Artifacts created by Luis and Taddeo as they prototyped their design.

To understand this interplay among perspective, material, and problem solving, we turn to Luis and Taddeo’s own recounting of their process of design and construction. On the final

day of the class, the students presented their work to an outside audience: teachers, administrators, and community members. Below are excerpts from our focal pair's description of their work, highlighting its development as it related to the work of other peer groups, different material forms, and concrete problems to be solved.

"It's like a map." Luis and Taddeo described the wooden platform they had created as a map that allowed them to try different solutions to the heating problem they had defined as the focus of their work. The platform was based on designs that other groups in the class were developing simultaneously; that would define the constraints by which their own solutions would need to operate in order to be true contributions to the class' shared construction.

Taddeo: At the time, we didn't know how big the bus stop was going to be. Depending on the structure team. We took the floor, and traced it, to start to get an idea.

Luis: We wanted to be more flexible. Our first idea was just to trace something. This gave us more freedom to put like this, or this [gestures to different configurations of heat tubing]."

In this way, the wooden platform served not only as a literal platform for Luis and Taddeo's potential engineering solutions, but also an instantiation of their solution that could be situated among the broader community project.

"What's going to heat the water in the tube?" By traversing a number of representations, prototypes, and functional models (Tucker-Raymond & Gravel, 2019), Luis and Taddeo also had opportunities to explore their working understandings of the scientific underpinnings of heat generation. Below, they respond to a guest who asks questions about how the heated tubing is expected to work.

Luis: We used, we used, well, he gave us another idea, which was the heat tape, um, or heat cable. Which we wrapped it around the tubes… The actual idea was the resistor, around the pipes, but we didn't have the resistor or something like that. Because, the bus stop has the electrical system, so the resistor would be collected to the electrical system.

Guest: When you say resistor, what do you, can you explain?

Taddeo: So, it would transform the electrical… oh my god, what's the name? [Facilitator suggests "Energy?"] … Energy! Electrical energy to heat … heating energy.

Luis distinguishes between heat tape and the "actual idea" that he and Taddeo considered for the bus stop, which involves the use of resistance to convert the electricity available at the bus station to create heat. In this way, he draws connections between the prototype and what aspects would carry over to the actual final design while maintaining the prototype as only a partial representation of the finalized conceptualization of the bus stop.

"Because you have to make it cool." Finally, the pair shared specific episodes of applied problem solving as they worked on their prototype. Below, they describe how they initially feared that the thermostat and heating mechanism in the prototype platform was not working. They realized that they had not completely explored how to control the heating element, requiring them to examine its thermostat at very low temperatures. These problem-solving challenges, interwoven with material considerations, helped the pair maintain strong connections between their prototype and the engineering task at hand, maintaining their construction's relevance to the initial problem of practice.

Taddeo: First we thought that it [the heating element] wasn't working, and then three days later.

Luis: We found out.
Taddeo: I don't know, a week later…
Guest: It was working?
Taddeo: Yeah, because we tried it again. And we leave it [the thermostat] on a long block. We leave it, like, a very long time. And we put ice.
Luis: In the ice, in the ice cup.

Examining the story these students told of their work reveals how the interweaving of perspective, material, and problem solving moved them not only toward engineering solutions but also toward making sense of the scientific principles that explain why those solutions work. The team's challenges, manifested through their need to communicate with others in order to define a problem space and solve practical problems, were immediate and acute. However, in reflecting back on the trajectory of their work, the story Taddeo and Luis told illuminated the underlying narrative relations. For example, the prototype became a template for thinking about

the problem. This “map” was a structure they populated with new ideas, materials, and problems (e.g., the heat tape failing to turn on), that made more visible the actual potential problems of building a bus stop.

Storytelling as a Design Tool

Engaging learners in collective constructionist activities in classroom settings can be difficult. The variety of directions that projects can take, and the different problems and material needs that arise along the way, can be intimidating for even seasoned educators. In this chapter, we introduce storytelling as a design framework for managing these challenges. Drawing from conceptualizations of storytelling that emphasize its collective, material, and problem-solving nature, we conceptualize constructionist activities as the production of material artifacts or texts that, when brought together, tell a story from multiple perspectives in ways that contribute explanations or solutions for shared problems.

This narrative approach to collective classroom constructionism can help guide the design and organization of classroom activities in a number of ways. First, it highlights the organizational and infrastructural benefits of having an explicit shared goal or common problem. In both of the cases presented above, learners were addressing very specific problems—the redesign of public bus stops, and an unknown ecosystem relationship. The specificity of these problems made it such that the learners had to not only understand but also rely on one another’s progress on the problem. Luis and Taddeo, for example, needed the constraints and material representation of the bus stop platform provided by their peers to gain traction on their own project.

Second, it highlights the critical role of materiality—both diverse, but also shared materials to express different perspectives or solutions—in supporting collective progress. In our own work, we have found that providing learners with particular material or representational forms can encourage them to focus on desired aspects of scientific systems (Wilkerson-Jerde, Gravel, & Macrander, 2015), and can facilitate the direct comparison or synthesis of explanations or solutions across groups (Wilkerson, Shareff, Gravel, Shaban, & Laina, 2017).

Finally, and most importantly for classroom instruction, a narrative approach highlights the importance of perspective taking in constructionist activity. While the philosophical and ethical components of perspective taking are often emphasized in the constructionist literature, the examples we present here highlight the pragmatic benefits of perspective taking—for helping learners to organize and distribute joint work, deepen student inquiry, and construct more robust explanations and solutions.

Acknowledgments

This work would not have been possible without our partner schools, educators, and students. Thanks to Eli Tucker-Raymond, Aditi Wagh, Ada Ren, and Vasiliki Laina for their involvement in the projects that yielded data for this chapter. This research was supported by National Science Foundation grants DRL-1422532 and IIS-1350282; any conclusions or recommendations are the authors' and do not reflect the views of UC-Berkeley, Tufts University, or the National Science Foundation. Mariana Levin introduced us to Bal's work on narratology years ago.

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