Research Article

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Inter-Organizational Design Thinking in Education: Joint Work between Learning Sciences Courses and a Zoo Education Program

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Abstract: A case study of design thinking in education considers how two educational organizations—a university graduate program and a public zoo—develop and enact design thinking processes in relation to one another. It also examines how this inter-organizational design thinking project contributes to a “center without walls,” or collaboratory (Wulf, 1993), pursuing an aspirational vision: to support interest-driven learning while also connecting youth to a wider landscape of formal and informal learning opportunities among educational organizations in a major US metropolitan area. As an initial step in pursuit of this vision, the work of the collaboratory concentrated on one of the zoo’s community-focused education programs called Overnight Adventure. Over seventeen weeks, the project involved the collaborative efforts of two faculty and twelve students from a college of education, and three full-time staff and nineteen part-time instructors from a zoo education program across ten inter-organizational events and observations of five Overnight Adventures. To characterize inter-organizational design, the case employs contiguity-based connecting strategies to analyze design thinking across four timescales. Findings describe the structures and processes of inter-organizational design thinking and the role of cultivating relational agency.

Keywords: design thinking, relational agency, collaboratory, zoo, learning sciences, infrastructuring.

1 Introduction

Metropolitan areas are expanding learning landscapes full of vibrant educational organizations. Each organization strives to inspire and enable interest-driven learning within the environments they design. However, many challenges, and incentives too, preclude the same organizations from helping youth extend their interest-driven pursuits to other organizations in the same metropolitan area. For example, providing high-quality experiences and environments at a children’s museum is challenging, as is sustaining enrollments in programs; therefore, additionally considering how to connect participants with learning opportunities beyond the museum requires time, attention, and funding that may not be readily available, let alone valued. Moreover, connecting learning opportunities may be a challenge that no single organization can address in isolation.

In response to these general challenges, this paper reports a case study of the work of two education organizations—a university graduate program and a zoo education program—to support learning within an educational organization while also exploring how to connect learning opportunities beyond the organization, across a metropolitan learning landscape. To engage in joint work, we enlisted the longstanding idea of a *collaboratory*, or “center without walls” (NRC, 1993; Wulf, 1993; cf. Muff, 2014; 2016), as a guiding concept to describe our work. A collaboratory organizes social and technological infrastructure that, in turn, gives rise to distributed networks of shared data and collaborative research. While new technological infrastructure has only augmented initial visions from the early 1990s, the kinds and degrees of knowledge generation, mobilization, and utilization envisioned a quarter century ago remain underdeveloped in education (Tseng, 2012), particularly among colleges of education (Fishman, Anderson, Tefera, & Zuiker, 2018; Zuiker et al., 2019). Therefore, design

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thinking (DT) is one approach that can shift problem-finding and -solving from researcher-led projects that organize a one-way process of disseminating scholarship to education stakeholders towards loosely structured design-led projects with the potential to organize a multi-way process of exchange among stakeholders.

With a view towards organizing more productive and consequential systems of exchange among education stakeholders, the sections below, first, resolve the purpose and guiding question of the study then, against this backdrop, review several lines of inquiry reported in the extant literature that, altogether, establish the intellectual merit of the study. Next, we introduce the context of the case and explicate a systematic approach to generating and analyzing data in order to characterize a well-bounded case. As a study of this case, our findings describe, analyze, and judiciously interpret inter-organizational DT along four different timescales. Finally, we discuss the implications and limitations of our case study.

2 Research Question

This case study considers how multiple organizations appropriate DT to mobilize knowledge in joint work around a common challenge. Specifically, two organizations (a public zoo education program and a university graduate learning sciences program) within the same US metropolitan learning landscape developed relational agency by utilizing DT together in service of opportunities for youth interest-driven learning. In comparison to studies of DT within organizations, exploration of inter-organizational DT that progresses across and in relation to two or more organizations is relatively neglected by DT scholarship thus far. Therefore, we consider inter-organizational DT, or how a use-inspired approach to educational challenges enables multiple organizations to think and act together, as a means of supporting learning and connecting learning opportunities. To this end, we ask: *how does design thinking organize an inter-organizational approach for (a) supporting learning and (b) connecting learning opportunities*. We engage the primary question of supporting learning in order to explore the secondary question of how inter-organizational DT might also consider fostering a culture for connecting learning opportunities within and among education organizations across a learning landscape.

3 Literature Review

With a view to our research questions, this section reviews extant literature about DT. It considers when and how DT emerged historically; its subsequent intersections with education; and its evolution among educators working in and out of school contexts, particularly learning scientists who employ design-based research methods. In relation to DT in education, the review concludes by considering a framework for how groups and organizations can relate to and work with one another for the purposes of DT. Against this backdrop, the study considers DT in education as it unfolds across two organizations working jointly on a common challenge: fostering opportunities for learning within an organization while also connecting them with additional opportunities beyond the organization.

4 Design Thinking and Education

The idea of design thinking (DT) has emerged and evolved in wide-ranging professional communities over more than a half-century. Its formal beginnings map back to the founding of the Design Research Society in the UK in 1967 and the Design Methods Group in the US in 1966 (Buchanan, 1992). As one early and seminal articulation of DT, Simon's (1969) *The Sciences of the Artificial* aimed to fill a gap between natural sciences and design practices. He proposed a science of design to formalize and optimize "the transformation of existing conditions into preferred ones" (p. 4). This visionary pursuit of what could or should be (rather than what currently is) is essential to DT projects. However, the process by which this visionary pursuit unfolds varies widely, and sometimes departs from Simon's articulation.

One noteworthy departure from the idea of design sciences is Schön's (1983) notion of the reflective practitioner. Schön critiqued the scientific pursuit of optimization, in part, because "[Simon's] science can be applied only to well-formed problems already extracted from situations of practice" (pp. 46-47). Rather than formal sciences of well-formed problems, Schön located design in reflective conversations with particular situations, conversations through which the designer plays a structuring role in framing the problem (Dorst, 2003). Design accompanies these conversations as they unfold in real-time and over time, giving rise to knowing-and-reflecting-in-action (Schön, 1983).

Like Schön, Buchanan (1992) emphasized that, while the scope of DT might be universal, its application remains

specific to situations and circumstances. Moreover, in contrast to “well-formed problems,” the situations with which designers converse are ambiguous, and often marked by uncertainty and instability. Conversations with situational particulars are therefore imperative if designers are to productively engage with ill-formed problems. Conversations are also integral because they “combine theory with practice for new productive purposes” (p. 6). Further, these conversations underscore the pluralism of views that inform design practices and purposes. Buchanan identified one such purpose as “sustaining, developing, and integrating human beings into broader ecological and cultural environments” (p. 10), which intersects the purposes of education.

DT within education illustrates an evolution similar to the general summary above. For example, Razzouk and Shute (2012) reviewed research on DT in order to identify characteristics of good design thinkers that might enhance student problem-solving. Consistent with Simon’s (1969) optimization strategy, if DT cognition can be formalized, then schools might be able to teach and assess it as part of problem-solving activities in curricula (e.g., Elwood, 2018). At the same time, Razzouk and Shute (2012) conclude their review by posing a question for future research: can DT be examined in general or is it inextricably bound to context? In this way, the relationship between context and DT in education suggests a tension between the general and the particular. It generally reflects the competing perspectives of Simon (1969) and Schön (1983), and serves to underscore that the role that context plays in design can vary. Despite these tensions, the ideas, tools, and processes of DT remain flexible, often eluding reduction (Buchanan, 1992). DT in education has, to date, skirted this tension, building on the work of Brown (2009), in order to popularize and mobilize complementary models developed by the design firm IDEO (2012) and Stanford University’s d.school (n.d.).

Drawing on this diverse literature, we emphasize basic elements of four seminal characterizations of DT in education. We enlist design as a means of exploring what could be rather than what is (Simon, 1969); we approach DT as an interactive conversation with the study’s situation (Schon, 1983); we loosely structure DT with established practices and tools (Brown, 2009; e.g., IDEO, 2012; d.school, n.d.); and finally, we concentrate on complex challenges facing education organizations who, themselves, design and sustain systems of teaching and learning that inspire and enable youth to contribute to broader cultural environments (e.g., Buchanan, 1992).

5 Expanding Design Thinking among Educators

Just as the conceptual scope of design thinking (DT) has expanded and evolved, so too have the roles of non-designers in the work of DT in education (Zuiker, Piepgrass, & Evans, 2017). For over four decades, the idea of participatory design has sought to expand involvement in design (Sanders, 2008) by positioning educational stakeholders with greater agency and with greater legitimacy than in traditional research-practice and/or design-practice. Participatory design blurs the lines between designer and non-designer by shifting design processes from research- to design-led approaches and from expert to participatory mindsets. In education, design-led approaches are exemplified by researcher-practitioner partnerships (Penuel & Gallagher, 2017) and participatory design research (Bang & Vossoughi, 2016) where joint work is mutually defined and refined. Pendleton-Julian and Brown (2018a; 2018b) argue that expanding design enables projects to engage a *social ecosystem*, which they describe as indivisible and interdependent social, political, and economic dynamics. Social ecosystems are therefore multidimensional and multi-scalar systems in which influences remain entangled and for which simple, direct causal relationships remain unlikely. Designing with social ecosystems such as metropolitan learning landscapes in mind can bring multiple organizations and stakeholders together in pursuit of agendas that no one organization could accomplish alone. In this way, ecosystem-oriented efforts contribute to research at the intersection of DT and the multiple organizations entangled in a social ecosystem.

Lines of inquiry into DT have established general ways in which DT efforts influence organizations. In a review of this literature, Elsbach and Stigliani (2018) distinguish long standing work on team-level DT within organizations from the influences of DT on organizations as a whole. They characterize two broad insights relating the culture of organizations to specific DT processes and practices. First, DT processes and practices give rise to an experiential learning process that triggers teams to think together about “what is going on here” (Weick, Sutcliffe, & Obstfeld, 2005). Asking and answering such questions can cultivate empathy, user-centric focus, collaboration, risk taking, learning, and openness to ambiguity within organizations. Second, DT processes produce not only physical artifacts (e.g., prototypes, sketches) but also emotional experiences (e.g., empathy, surprise) that can illuminate how and why DT contributes to the work of an

organization. These two broad insights relating DT and organizational culture illustrate how DT can open up reflective conversations with situations (i.e., Schön, 1983) to a wider range of stakeholders. These insights provide support for organizing a collaboratory that involves multiple organizations and stakeholders (Muff, 2014) around DT processes and practices. These same insights also reflect complementary intuitions about the role of design in educational research, particularly the learning sciences.

6 Design Thinking and the Learning Sciences

Drawing on design fields, the learning sciences enlist design to bring about new forms of learning and teaching and, therein, to better understand how design mediates learning and teaching (Cobb et al., 2003). The role of design in the learning sciences has evolved in ways that reflect other design fields (e.g., Sanders, 2008), namely shifting from researcher-led “ego systems” to design-led ecosystems (Zuiker, Piepgrass, & Evans, 2018). Design-led projects organize and sustain systems of exchange among stakeholders directly involved in or indirectly impacted by a design agenda. One example of such an approach is *infrastructuring* (DiSalvo & DiSalvo, 2014; LeDantec & DiSalvo, 2013). Whereas many forms of participatory design focus on practical innovations that are immediately useful, infrastructuring also seeks to enable “adoption and appropriation beyond the initial scope of the design, a process that might include participants not present during the initial design” (p. 247). In this way, infrastructuring concentrates on design as ongoing socio-technical processes rather than a fixed project. Its impact on educational change is “to create fertile ground to sustain a community of participants” (p. 247).

Infrastructuring can also extend the reach of design by expanding its focus. By including wide-ranging stakeholders, it shifts the focus from singular, partial perspectives that frame known opportunities and challenges to multiple, partial perspectives with the potential to illuminate unknown opportunities and challenges as well. In this way, a researcher’s role is not only to foster and contribute to participatory design processes but to develop social and technological infrastructure that can sustain these processes beyond the life of the project. Using DT can contribute to a social infrastructure by organizing experiential learning and producing both physical artifacts and emotional experiences that,

together, can transform the culture within and among education organizations (i.e., Elsbach and Stigliani, 2018). One aspect of this social infrastructure is the ways individuals and organizations not only think or reflect together but how they act in relation to one another.

7 Relational Agency for Design Thinking

Inter-organizational design approaches to transforming educational possibilities require a collective capacity for working together through multi-organization collaboration. To this end, one framework in supporting the work of youth-serving organizations to co-design socio-technical processes for educational change is that of relational agency. Edwards (2006) defined *relational agency* as “a capacity to offer support and to ask for support from others” (p. 168), with the result that people and organizations’ engagement with the world is enhanced. A construct arising out of scholars’ consideration of inter-organizational cultural-historical activity systems, relational agency is concerned with distributed and “purposeful practice with others” across multiple organizations (Edwards, 2007). Its matter of interest is how practitioners across multiple systems adjust their actions in response to inter-organizational collaborators’ needs and strengths. Emphasizing interaction locates the efficacy of unfolding social relations over the autonomous reflexivity of individual agents (Burkitt, 2015); relational agency emerges in the relationships among agents mutually committed to a complex social problem. Generating relational agency requires willingness to put a complex social problem at the center of a set of relationships. Aligning their responses to an evolving situation, people can alternately step in and stand back for the good of a common problem (Edwards, 2010). Intentional oscillation becomes possible because relational agency advances understanding of others’ ways of working, their expertise and purposes relative to a wicked problem.

Positioning agents in a local ecology to engage in the demanding work of growing a local youth learning landscape demands the cultivation of dispositions, commitments, and capacity to seek and support relational agency across co-located organizations whose members are mutually committed to similar social agendas (see Edwards, 2010). We see inter-organizational approaches to DT as enlisting individual and collective intellectual agency to re-mediate relational agency among and

with other stakeholders. Because learning landscape collaboratories seek to develop technological and social infrastructure that sustains and extends any specific joint project, organizational partners will benefit from enlisting relational agency to remediate any particular stakeholder's intellectual agency at any point along an unfolding design process. Thus, bolstered by understandings of relational agency, we see potential in helping organizations recognize their interconnectedness and relational responsibility in co-designing innovations that foster local youth-serving learning landscapes.

8 Context of the Case

Our case study considers a DT project in education that is embedded within a wider inter-organizational effort between members of a public university and a public zoo, what we came to call the *DT collaboratory*. Members included 2 instructors and 12 graduate students associated with two education courses as well as 3 full-time lead staff and 20 part-time instructors associated with the zoo's education programming. Because the project emerged and evolved in relation to both organizations, we characterize our case as one emerging in relation to a socially co-constructed context. We, therefore, did not predetermine the boundaries of the case or the context (e.g., Wells, Hirshberg, Lipton, & Oakes, 1995); instead, we enlisted design thinking in education to theoretically guide the progressive delineation of boundaries over time (Miles & Huberman, 1994).

In this sense, we seek to research a specific, well-defined case of DT in education while also recognizing that it can inform wider efforts among additional education organizations operating in the same metropolitan area as well as other metropolitan areas. Our aspirational vision is to make connections among education organizations matter more for youth in a US metropolitan area. We presume that any metropolitan learning landscape is dynamic and therefore conjecture that a sustainable and transformative agenda must consider a learning landscape as an interdependent learning ecosystem. Youth and education organization are therefore units of concern, but the systems of exchange and webs of reciprocity among them constitute our unit of analysis. To this end, our work began by convening events that provided education organizations within a single metropolitan area with opportunities to share perspectives and exchange ideas. The salon-like conversations we describe below served to seed a transformational vision

of a metropolitan learning landscape while also exploring practical strategies to develop organization-youth and organization-organization reciprocity advantages within that landscape. The DT Collaboratory work described in this study emerged and developed against the backdrop of these wider efforts. Thus, in the sections below, we first describe our broad-scale efforts to seed connections across a metropolitan learning landscape in order to contextualize the DT Collaboratory's inter-organizational approach to supporting learning and connecting learning opportunities. We then describe the more localized organizational context in which the collaboratory's DT work was situated.

9 Seeding a Transformational Vision of a Metropolitan Learning Landscape

Our project emerged in relation to common interests around supporting learning in specific local sites and connecting learning opportunities across sites in a larger metropolitan area. The first two authors, both educational scholars, collaborated with two leaders of educational organizations, one from a large formal organization and the other from a rural informal organization. Together, they organized a learning landscapes initiative in their shared metropolitan context, convening three events with leaders from 40 local education organizations in order to engage in DT processes. These preliminary events included a 60-minute invited DT workshop in which participants shared experiences of cross-organizational collaboration and explored potential network connections to foster youth learning, a 90-minute public design challenge (see below), and a 45-minute symposium at a state-level education conference wherein workshop leaders presented illustrative examples of relational agency across co-located organizations mutually committed to youth learning. In order to build relationships and trust among education organizations, we enlisted DT as an approach and a mindset for organizational leaders to consider how they might organize a more connected local learning landscape for youth.

As initial efforts that set the state for our case below, each event fostered awareness, interest, and insight by exploring questions. In the initial workshop, organization leaders considered the guiding question: how do youth experiences within my organization enable them to pursue their interests beyond my organization? To explore

Figure 1: Images of the learning landscapes actor map activity model (left), participant data (middle), and digital map (right).

this question, workshop participants participated in three activities. For example, they identified key stakeholders for their organizations and the wider metropolitan area in order to co-construct a learning landscapes “actor map”, thereby fostering empathy for a metropolitan learning landscape. Participants in the design challenge event reviewed and expanded an interactive version of the map. Figure 1 presents a series of artifacts, including the initial actor map models, insights participants generated at one workshop table, and the web-based interactive map we circulated and further expanded during the design challenge and subsequent events.

The design challenge engaged approximately three times as many organization leaders in a more formal design challenge, in part using the digital map in Figure 1 above. The written challenge presented to participants follows below.

The metropolitan learning landscape is rich with opportunities, and it is continuing to expand. But how can we create a smarter, more connected learning landscape? How can we make our connections matter for youth? This design challenge seeks to develop an urban educational system where all learners have access to customized and engaging resources that support ongoing learning and development. While all youth are curious and interested, the opportunities and resources available can be challenging for them to identify or pursue. However, youth live in a world of abundant learning, unlike any other time. How can youth identify opportunities and forge pathways that enable them, as individuals or as groups, to pursue their interests and passions? As leaders of learning organizations, what can we do together in order to make our connections visible and actionable to youth? As a design team, consider the solutions to the following three guiding questions:

1. How should organizations connect?
2. How should our connections matter for youth?

3. What small moves will make connections matter more for youth?

While discussions during this design challenge varied due to the fact that DT was new to some and familiar to others, they enabled participants to relate to one another and develop shared focus while also articulating several possible ways to exercise agency as individuals, teams, and whole organizations. A shared focus more immediately enabled us to engage in a process of imagining future possibilities and designing minimum viable changes that would enable multiple organizations to pursue these possibilities. In other words, we sought to develop small but coordinated multi-organizational efforts along the edges of each participating organization (away from core activities and budgets) where the opportunity cost of risk and failure was low but the potential for learning and insight were high. Organizing a DT Collaboratory was one such change.

10 The DT Collaboratory Emerges

Among the conversations seeded through the initial metropolitan learning landscape efforts, the university partners discussed the general idea of initiating a collaboratory with a member of the zoo education staff who participated in the public design challenge. Subsequently, she and her team invited us to collaborate around their Overnight Adventure (OA) education program over a four-month university semester. The OA program represented a promising starting point. With a 50-year history, the zoo is a longstanding educational organization with a prominent public presence and OA has been its flagship educational program for over 25 years. Specifically, OA is an overnight field trip for grade-level communities (i.e., teachers, students, and parent-chaperones). Programming explores

environmental conservation themes through three interconnected activities: hikes in relevant areas on the zoo, interactions with ambassador animals, and inquiry via scientific experiments. By leveraging zoo resources in these ways, OA supports rich and engaging experiences that often spark or further fuel interests for over 5,000 students annually. However, anticipating what kinds of interests emerge through students' engagement in the three types of OA activities, let alone leveraging these interests to inspire and enable interest-driven pursuits across a learning landscape, remains challenging. The zoo's own portfolio of education programs is one obvious network with which to connect youth interests but how might any educational organization connect varied youth interests with relevant opportunities beyond its own boundaries?

In pursuit of the twin aims of supporting interest-driven learning and connecting learning opportunities across a metropolitan area, our project collaboration was guided by two key assumptions. First, any system of learning and teaching is improvable. We did not assume that the OA program was broken or deficient but rather that it was complex and imperfect. Second, a short-term project without a budget can think big but must start small by concentrating on modest changes with the potential to advance an inter-organizational shared focus.

As the context for our case, this section communicated that we sought to advance a shared focus by organizing a collaboratory for DT in education. As provisional responses to the opportunities and challenges of developing a more connected learning landscape, our case study of one DT project characterizes how two organizations came together in order to support interest-driven learning while also considering how to connect opportunities across a wider learning landscape in a major US metropolitan area

11 Case Study Methodology

Our review of the literature establishes that much is known about the practices of DT but less is known about how organizing inter-organizational collaborations enact these practices. As a case study of DT in education, we focus on inter-organizational processes of thinking and acting together and in relation to one another. In particular, we consider the implementation process and its contributions with respect to our wider aspirational vision. Our focus on inter-organizational activities therefore leads us to analyze interactions among participants during events and in relation to one another as intra-organizational

activities unfolded in support of the DT agenda. The scope of the case is a 17-week period of time. This span includes the work of both learning sciences courses during "peak season" for the OA program, encircled by pre-planning and post-project events involving leaders of both organizations.

12 Participants

The project involved two organizations: a university graduate program and a public zoo education program. The university leaders were the course faculty (Zuiker and Jordan). The zoo leaders were full-time education staff responsible for organizing and coordinating OA sessions, and one part-time OA instructor with three years prior experience. 12 graduates students in theory and methods courses, respectively, and 19 additional camp instructors with 1-20 years prior experience also participated. Approximately 350 students (roughly 7% of total annual OA attendees), teachers, and parent-chaperones from five elementary schools (including private, charter, and public schools) participated in the OAs that we observed with groups ranging in size from approximately 30 to 150 students.

13 Data Generation

Reflecting a major strength of case study research (Yin, 1994), we generated multiple forms of data related to the focal inter-organizational events study as well as intra-organizational activities that prepared collaboratory members to contribute to and leverage what occurred during inter-organizational events (See Table 1 below). For the events that contributed to the DT project, we generated audio and video recordings of two panel discussions, two prototype critiques, three prototype testing phone calls, and two instructor workshops. We also generated audio and video recordings of intra-organizational activities that occurred among university members, as well as written artifacts that recorded reflective actions and thinking generated in relation to the activities (e.g., emails, slides, notes). Beyond these events and activities, we also generated data while observing five OAs with five grade-level communities from separate schools (approximately 350 participants total). Importantly, we list these observations in Table 1 because they are a critical foundation for joint work; however, they also precluded inter-organizational engagement, let alone contributions,

Table 1: Timeline for Inter-Organizational Events and Intra-Organizational Activities.

Week	Inter-Organizational Events	Intra-Organizational Activities
Pre	Planning Meeting #1 Planning Meeting #2	● Collaboratory prototype presentation ● Multi-course project timeline and contributions
1		1. content inventory & analysis 2. panel discussion protocol
2	Overnight Adventure Leadership Team Panel Discussion	3. data-driven thematic analysis of panel discussion 4. zoo and camp context description
3		5. camp curriculum content analysis 6. further analysis of panel discussion
4	Overnight Adventure Observations #1 and #2	7. theory-driven coding of panel discussion
5	Overnight Adventure Observations #3	8. methodic logs of 3 types of camp activities; initial collaborative analysis
6	Cycle 1 Prototype Critique	9. theoretical analysis of camp observations & cycle 1 prototype “sketches” 10. transcripts of Cycle 1 observations; collaborative analysis of interactional patterns and structures; derived list of needs and opportunities
7		11. refine cycle 1 prototype via discussion 12. microanalysis of recurring patterns; brainstorm opportunities for learning
8	Cycle 1 Faculty-Staff Prototype Testing Phone Call Cycle 1 Instructor Workshop	13. refine cycle 1 prototype via discussion 14. Cycle 1 collaborative analysis based on prototypes 15. develop instructor feedback survey
9	Cycle 1 Overnight Adventure Observation	
10		16. discussion of cycle 1 observations 17. collaborative analysis of instructor survey data
11	Cycle 2 Prototype Critique Session	18. theoretical analysis of cycle 1 observations & cycle 2 prototype “sketches” 19. methodic logs of camp activities and collaborative analysis based on prototypes
12		20. refine cycle 2 prototype via discussion 21. refine cycle 2 prototype via discussion
13	Cycle 2 Faculty-Staff Prototype Testing Phone Call Cycle 2 Instructor Workshop	22. refine cycle 2 prototype via discussion 23. develop cycle 2 evaluation strategies
14	Cycle 2 Overnight Adventure Observation	24. discussion of cycle 2 instructor workshop 25. evaluate cycle 1 innovation
15		
16	Overnight Adventure Leadership Team Panel Discussion	
17		26. theoretical analysis of cycle 2 observations and project website 27. author study methods pastiche of cycle 1 and cycle 2 observations
Post	Data Analysis Working Session #1 Data Analysis Working Session #2	● Meeting agendas, notes, and data analysis

because each organization worked separately and not relationally.

14 Data Analysis

The analysis was guided by our question about how DT in education fosters and sustains inter-organizational processes for acting together and in relation to one another. After sorting and organizing the data as a complete case record, multiple intermediate analytical steps transformed the data, therein progressively sharpening the focus and narrowing the scope of the data

we analyzed. For these intermediate steps, we followed a general relational analysis by employing contiguity-based connecting strategies (Maxwell & Miller, 2008). In our case, such strategies constitute a comprehensive, systematic, and in-depth effort to connect temporal processes by means of juxtapositions and linkages. Based on these connections or relationships, we tie data together into sequences and progressively eliminate unrelated data. For example, Erickson (1992) considers the organization of social processes by examining “whole events, continues by analytically decomposing them into smaller fragments, and then concludes by recomposing them into wholes [This process] returns them to a level

Figure 2: Summary of progressive data analysis by timescale.

of sequentially connected social action” (p. 217). In this way, data is segmented and then connected in a relational order while also remaining contextualized.

To summarize our relational analyses, we segmented our data into four levels of analysis depicted in Figure 2 below. We also elaborate on the methods in the findings section. At the first level, we focus on the collaboratory as a holistic project in order to characterize inter-organizational processes. At the second level, we focus more closely on inter-organizational DT from month to month by segmenting the events and activities that contribute to the project. At the third level, we further sharpen our focus to the two project design cycles unfolding week-to-week across 6 and 3 weeks respectively. Importantly, at this level, we also not only transform data but also reduce data by deliberately omitting events and artifacts that did not directly inform the cycle-level analysis. Finally, at the fourth level of analysis, we concentrate exclusively on particular DT activity segments from moment-to-moment as they unfolded within 3 separate events.

To support each level of analysis, we tabulated the inter-organizational events (see Table 1) using content logs to describe social interaction over time (Jordan & Henderson, 1995) then selectively transcribed events or event segments that related to our research questions. We also tabulated intra-organizational activities (see Table 1) with descriptive summaries of the goals, process, and artifacts. Throughout our analysis, we iteratively examined inter-organizational events and intra-organizational activities, tacking between sequential comparison across multiple timescales in order to identify and characterize contributions to inter-organizational DT (i.e., what was pulled forward to the next level of analysis).

Drawing directly on these levels of analysis, the case presentation below takes the form of a four-part chronology that examines the collaboratory with respect to each timescale (cf. Shroyer, Lovins, Turns, Cardella, & Atman, 2018). Figure 3 below provides a summary representation of our relational analysis by identifying each level in the left-hand column and graphically representing our segmenting strategy in the right-hand column. We elaborate on Figure 3 as we present each level of analysis. Lastly, our goal in conducting this multi-timescale analysis is to describe a novel case of DT in education; our descriptions preclude generalizing about DT in education (Stake, 1995; 2000).

15 Findings

The Learning Landscape Collaboratory involved members of two organizations in the joint work of thinking and acting relationally. Both organizations contributed in relation to a common DT project; they also contributed in relation to one another to pursue a shared vision of a city-wide youth Learning Landscape initiative (see Context of the Case section). The findings report successive level of analysis that describes how these organizations appropriated DT tools and practices to advance an inter-organizational approach for supporting learning. In so doing, the findings also lend insight into how DT might also foster an inter-organizational culture for connecting learning opportunities across an extra-organizational learning landscape.

Figure 3: Representing Contributions to Inter-Organizational Design Thinking Project across Four Timescale Levels.

16 Level 1: Design Thinking Collaboratory

While DT is the focus of our analysis, it is likewise critical to understand the general intentions of the participants as much as the specific actions taken. In other words, shared intentions do not directly translate into joint work. The first level of analysis therefore provides a holistic consideration of the inter-organizational DT collaboratory before, during, and after the 17-week span of events and observations. We reviewed meetings slides, notes, and

other materials in artifact sets from inter-organizational planning meetings and course planning meetings before the DT collaboratory started as well as debriefing and research meetings after the DT collaboratory ended. At this level and with these data, we therefore ask: how did joint work emerge and evolve among multiple organizations? To answer this question, we briefly review the events leading up to the collaboratory, the intentions of program faculty and zoo staff that determined the project scope, and ultimately still more events following after the collaboratory.

The collaboratory directly capitalized on the preliminary workshop, design challenge and symposium presented in the context of the case. More broadly, these preliminary events and the idea of a connected learning landscape resonated with interests already circulating among some leaders across metropolitan education organizations, including the zoo staff. These complementary intuitions established shared intentions among the faculty and staff to locate joint workaround how to connect learning opportunities for youth in the relatively small-scale, short-term activities of the zoo's OA program. At the same time, even a single OA experience involves many individuals interacting over 5 hours of programming, challenging collaboratory members to further scale down the focus of collective efforts.

In order to resolve a productive scope for joint work, faculty and staff agreed to focus on supporting learning in order to achieve direct, near-term benefits (i.e., enhancing youth experiences during OA activities as described in subsequent levels of analysis) while still considering how these supports can inform longer-term efforts of other education organizations in the same metropolitan area. In thinking both about and beyond OA, the collaboratory model might begin to develop a modest social and technological infrastructure that is as dynamic and interdependent as the learning ecosystem it serves. This aspirational vision is admittedly ambitious, but not naive; it presumes that “the actual limits of what is achievable depend in part on the beliefs people hold about what sorts of alternatives are viable” (Wright, 2010, p. 23). Joint work therefore concentrated on small innovations that would permit us to couple thought with action. Such modesty translated into small (but not necessarily simple) moves that enabled us to remain flexible and adaptive to the changes an innovative move introduced and, in turn, to evolve understanding of the very field of available opportunities and challenges that shape minimum viable transformations of OA programming.

Concretely, OA organizes several programs, each one a self-contained system of teaching and learning. We concentrated on a single OA program with multiple hikes, multiple interactive experiences with animals, and a hands-on scientific experiment. Within this OA program, we narrowed the focused to component features and themes that emerged through observations. As an example of one component feature that emerged and is discussed further in subsequent levels of analysis, Figure 4 below captures two OA instructors as they move around a circle of students with a small animal during an Animal Discovery activity.

Figure 4: Initial observation of zoo instructors facilitating an animal discovery activity during Overnight Adventure observation #1.

The Animal Discovery activity creates an opportunity to observe and carefully interact with an animal. At the same time, it is also an occasion to construct and share questions and ideas and also to engage with the questions and ideas raised by instructors and peers. The inter-organizational challenge during initial observations entailed identifying or conceptualizing component features of the OA program like this Animal Discovery activity and considering how we might refine it in order to enhance near-term opportunities to learn and, in turn, begin to connect this small-scale opportunities with the wider landscape of learning opportunities available to elementary and middle school students in the metropolitan area. As subsequent levels of analysis zoom in on the inter-organizational DT project, we will characterize how the initial shared intention of faculty and staff further resolved the scale and scope of joint work in relation to these qualifying remarks. This holistic account illustrates that shared intentions are an important foundation for joint work but, at the same time, that joint work remains organized around the specific features of the designed systems of teaching and learning that operate in an education organization.

Before zooming in to the next level of analysis, we conclude this holistic account by characterizing how joint work progressed after the collaboratory DT project concluded. At the end of seventeen weeks, over 40 collaboratory members had contributed to the co-construction of a shared understanding of OA. The zoo education staff published an article about the collaboratory in an Association of Zoos and Aquariums newsletter that is circulated nationwide to association educators. They also featured the project in grant proposal narratives that support the zoo's education programming. Meanwhile, faculty organized a series of data analysis work sessions among graduate student members, with initial

contributions from the zoo education staff. These sessions formally analyzed the system of teaching and learning operating in the OA (Zuiker, Jordan, Accettaa, Sanders, Li et al., in preparation) in order to contribute to ongoing scholarly conversations about the many sites of teaching and learning (e.g., NRC, 2009). These separate agendas also demonstrate how both organizations established common ground and a concrete foundation on which future agendas in this metropolitan area can build the collaboratory model and advance the aspirational vision of the Learning Landscapes initiative. As such, the project serves as an example of how inter-organizational DT can work to other education organizations in the metropolitan area. In relation to this holistic account, the remaining levels of analysis zoom in to consider joint work and the inter-organizational DT project that emerged.

17 Level 2: Inter-Organizational Design Thinking Project

As the collaboratory progressed, shared interests coalesced into joint work around a concrete design project. This section therefore provides specific details about the process of designing and thinking together. First, we summarize the data enlisted. Next, we characterize the interplay between convergent and divergent thinking that advances joint work and common focus. Finally, we consider the inter-organizational dynamics underlying focused work in order to illustrate how relational agency unfolds among collaboratory participants.

Data organized at the project level. To characterize the process of inter-organizational DT, we chronologically reviewed all 8 interorganizational events. We also reviewed and summarized artifact sets from 27 course activities that either directly contributed to these events or indirectly enhanced faculty and student understanding of OA. Based on this review, we concluded that all 8 events but only 10 activities contributed directly to inter-organizational DT. (Importantly, while all five OA observations technically constituted inter-organizational events too, we focused on youth, teacher, and chaperone experiences, precluding opportunities to think together across organizations.) Table 1 chronologically orders and individually numbers all events and activities. Meanwhile, the level 2 analysis represented in Figure 3 indicates activities by number below each inter-organizational event to which they contributed. We draw on these events and activities to characterize the arc of the collaboratory's inter-organizational project and then zoom in to understand how inter-organizational

DT relied on cultivating relational agency between the partner organizations.

The interplay between convergent and divergent thinking. Convergent and divergent thinking about design reflects the sequence of these collaboratory events and activities as well as the interleaving OA observations and implementations. Broadly, inter-organizational DT entailed two design cycles of critique-test-workshop events (see level 2 analysis in Figure 3) bookended by panel discussion events. In addition to these events, collaboratory members gathered to strategically observe OAs before and then during each design cycle. For the preliminary observation, graduate students were divided in order to attend three separate OAs. Each graduate student attended a 4-hour sequence of OA activities (see initial OA observations #1-3 in Table 1). Each OA illuminated how its system of learning and teaching operated somewhat differently based on the uniqueness of each grade-level community as well as the ways OA activities (i.e., hikes, animal discoveries, and experiments) varied under different practical, circumstantial, and social conditions. Similarly, observations during cycles 1 and 2 illustrated how prototyped designs influenced both these conditions and the OA system.

Against this backdrop of events, activities, and observations, we illustrate convergent and divergent thinking in terms of a first project-level feature: co-generating the project focus. While we concretely characterized youth-instructor discussion patterns as the common focus of joint work above, here we further unpack this emergent focus in relation to the wider backdrop of collaboratory events and activities. When two or more organizations come together to design around an issue of shared interest, much effort is expended to understand the situation they are jointly working to enhance.

In this project, jointly narrowing the project to a common focus began immediately during the first panel. Members of both organizations worked together to frame what OA currently is and to develop a shared imagining of what it could be (Simon, 1969). In fact, the majority of the 65-minute panel concentrated on mutual efforts to build a common understanding of the social, organizational, and structural context of OA, including zoo leaders' commitment to supporting learning now and in the future. These convergent efforts were bolstered by preceding intra-organizational activities in which graduate students reviewed zoo documents and materials then crafted panel questions ranging from financial to technical to social-interactional topics.

Meanwhile, subsequent OA observations fueled divergent thinking as graduate students considered

social interactions within and across the three primary OA activities—hikes, animal discoveries, and scientific experiments. The wide-ranging social interactions observed led the graduate students to characterize and contrast current discursive patterns in student, teacher, and chaperone engagement with zoo instructors during each activity. Taken together, convergent thinking during the panel, coupled with divergent thinking based on initial OA observations, illustrate how design thinking can challenge individuals, groups, and, in this case study, separate organizations, to iteratively define and refine problems and solutions.

Course debriefing conversations following initial OA observations, in turn, fostered convergent thinking among the graduate students. For many, the initial focus on patterns of engagement between instructors and grade-level communities narrowed to enhancing youth-instructor discussion patterns, namely shifting from instructor-centered (e.g., Mehan, 1979) towards student-centered discussions. Figure 4 above, for example, is a single image from a time-lapse video that illustrates an instructor-centered discussion pattern. In this specific instance, instructor A walked the inner edge of the student circle three times in order to present the animal while discussion centered around instructor B, who intermittently posed questions to or answered questions from individuals with a raised hand.

However, convergent interpretations around instances like this gave way to divergent thinking again, as graduate students' efforts to prototype solutions wrestled with wide-ranging possibilities despite narrowing the scope to youth-instructor discussion patterns. Specifically, the graduate student prototypes present simple but varied processes for learning and teaching with the potential to enhance OA experiences for youth. Figure 5 features a row of thumbnail-views of the general storyboard configurations. The thumbnails include three- and six-panel stories that illustrate contrasting prototypes of new instructor practices that might shift youth-instructor discussion patterns during OA activities. Zoo staff pragmatically engaged each prototype during the subsequent critique session. They readily adopted some prototypes such as using new terminology that better recognizes diversity and promotes inclusivity. Zoo staff also reframed some prototypes, often in relation to opportunity cost of implementing the innovation. For example, a proposed innovation might complicate a linear process, replacing a simple task with a contingent one during a time-sensitive activity. The range of prototypes in Table 5 reflects the wider range of design innovations and how they engaged OA as a social ecosystem (Pendleton-

Julian and Brown, 2018a; 2018b). Design cycle 1 prototypes specifically aimed to influence learning and teaching with respect to multiple social and political dynamics.

Figure 5 also presents a full view of the prototype that collaboratory participants ultimately adapted and instructors implemented in design cycle 1. This full prototype proposed to incorporate a common classroom structure called think-pair-share whereby individuals consider their own personal answers to a question, pair up to articulate their ideas to a peer, then the instructor invites pairs to share one or more of their ideas. As another example of convergent thinking, this prototype further resolved joint work and common focus. At the same time, it underspecifies how to systematically integrate think-pair-share structures into OA activities, which vary from the classroom context where think-pair-share is widely used (e.g., Schwan, Grajal, & Lewalter, 2014). This emerging project scope continued to evolve as progressive interplay between convergent and divergent thinking advanced.

The project scope specifically advanced through iterative efforts to design possibilities for discursive interactions across both cycles of prototyping, critiquing and testing. In particular, each critique event invited zoo leaders to evaluate prototype “sketches” developed by students during intra-organizational prototyping activities (see Table 5). The critique events therefore organized a forum through which to collectively examine, explore, refine, merge, and create new ideas. Each critique was followed up by a test of selected design ideas in virtual meetings between faculty and zoo leaders - the only inter-organizational events for which only a small subset of organizational members participated. Course faculty and students enlisted the critique and test events to refine and organize prototypes to test during instructor workshop in each DT cycle.

DT processes developed a set of tools to support instructors in shifting discourse patterns during camp activities. Specifically, the first was a “toolbox” of task structures (e.g., questioning strategies, seating arrangements) on think-pair-share discussion processes that served to encourage student-centered discourse. The second was an additional feedback and reflection document. As a written response to four general questions, the document provides a mechanism through which instructors could share insights into and adaptations of the toolbox via a post-OA reflection sheet in cycle 1 and graphic representations of each think-pair-share tool posted in a shared space for cycle 1. In this way, the broad project structure enabled both organizations to engage in, refine, and evolve joint work before, during, and after each DT cycle. In comparison to the more practical

Figure 5: Three illustrative thumbnails of graduate student storyboard prototypes from the cycle 1 prototype critique event and a full-size storyboard prototype further adapted and implemented in the cycle 1 Overnight Adventure.

innovations in the toolbox, the feedback tool serves the broader scope of infrastructuring (DiSalvo & DiSalvo, 2014; LeDantec & DiSalvo, 2013). It is integral to designing for social ecosystems because involves collaboratory members beyond any specific instantiation of OA and emphasizes an ongoing, collective process of refinement, underscoring our complementary focus on how relational agency influenced collaboratory inter-organizational events across the project.

Cultivating relational agency at the project level.

The second project-level feature we consider is the process of cultivating relational agency (Edwards, 2005). A non-trivial proportion of each event involved a combination

of facilitating inter-organizational DT and reflecting on what inter-organizational DT obscures and reveals. We consider facilitation and reflection with respect to the key role of cultivating relational agency in grounding an inter-organizational approach to DT. This includes how collaboratory members attempted to align their “thought and actions with those of others in order to interpret problems of practice and to respond to those interpretations” (p. 169) while attempting to bring forth a collaborative DT project. Several exemplars highlight how the course faculty facilitated relational agency by framing events and positioning collaboratory members as contributors to an inter-organizational culture of DT.

First, faculty worked to cultivate the collaboratory's capacity for relational agency through the event facilitation strategy of framing. Faculty framed each inter-organizational event in terms of the DT process that preceded, accompanied, and followed after it. Specifically, faculty verbally contextualized the goals, tools, and practices associated with an event in relation to the wider inter-organizational DT project, often beginning and ending events with a broad description of the overall process of DT, followed by zooming in on the particular DT process of concern for the event immediately at hand. Such high-level framing of DT, coupled with an explicit expectation of shared exploration of possibilities, helped ensure that all collaboratory members shared an understanding of the arc of their joint project work, and could, therefore, contribute on a more equal footing. Indeed, such framing may have facilitated relational agency enacted through oscillations between stepping back and stepping forward to further inter-organizational goals (Edwards, 2010). While the university partners were by definition the instigators of the initial prototypes for the DT project, we saw instances of faculty and students "stepping back" in response to zoo members "stepping forward" to contribute to co-creating design ideas. We also saw the cultivation of relational agency in the oscillation of faculty versus student leadership in directing inter-organizational events. Specifically, both faculty members played significant roles in organizing and implementing the cycle 1 instructor workshop, whereas the learning sciences students took over these roles for the cycle 2 workshop. In this way, relational agency was further dispersed and deepened among a greater proportion of organizational members over time.

Faculty also cultivated relational agency by frequently expressing admiration and respect for the work of OA leaders and instructors, coupled with articulating the value that all ideas are improvable. At one critique event, an instructor emphasized, "we're not here with the solution to something that's broken that needs to be fixed...we saw that you are already really powerful and successful in what you're doing." Moreover, faculty framed not only the zoo members' professional practice, but also the university design partners' ideas as continuously improvable, as "useful for getting started" in learning together and to go from good to great. Such framing helped to develop trust that could be leveraged to further increase the collaboratory's capacity for relational agency.

Another often iterated act of fostering relational agency was explicitly managing expectations within the short 17-week timespan of the project. Faculty made reference to the appropriately limited scope of the project

aims at all events, offering not only time constraints as a limiting factor in the design scope, but also the nature of the DT process itself. Faculty frequently communicated that the goal was to develop small moves that, if smartly made, could lead to larger change over time.

With an orientation to the future and an expectation of ongoing relationships among trusted partners, strength drawn from relational agency helped collaboratory members re-define and evaluate the minimum viable transformation of OA in the pursuit of their jointly envisioned influence on wider systems of support and connection. As evidence that relational agency was an issue of joint consideration during the cycle 2 panel, one zoo leader retrospectively revealed her initial worry that the university faculty and students would not be able to understand the complex and contingent facets of OA, a worry that was alleviated through ongoing collaboratory interactions. We also see evidence of the collaboratory's growing capacity for relational agency in zoo and university partner reflections. As one student expressed about their experience in the cycle 2 panel,

We were able to share with [the zoo leaders] what we thought went well and what we thought could have been better... I also thought it was really kind of them to ask us what we got out of this experience. It's nice that they actually care about that and wanted the relationship we built to be mutually beneficial.

These and other reflections illustrated the consideration given not only to interorganizational caring for the project, but also to caring for the relationships cultivated through the shared experience.

Together, these project-level insights illustrate how an inter-organizational approach to DT co-generated common focus emerged and folded and the role that cultivating relational agency played therein. These insights underscore that understanding a context for design cannot simply be assumed or acquired easily; neither do trust and capacity for joint action emerge spontaneously. Rather, they depend on inter-organizational capacity for responding to partners' strengths and needs in ways that support not only a collective project, but also the continued cultivation and maintenance of ongoing collaboratory relationships.

We conjecture that inter-organizational DT in education entails not only tools and practices that organize an approach but also an extra-organizational culture that reflects efforts to think about wider social ecosystems; and to think both about and beyond the separate, often competing interests of each educational organization. In this way, cultivating a collective capacity for multi-organizational collaboration on a DT project

simultaneously fosters a culture that organizes DT as an inter-organizational approach for supporting learning within the boundaries of joint work and common focus; but perhaps beyond it as well, with a view to a wider opportunities that can benefit youth across the metropolitan area. We suggest that such a culture is necessary if multiple education organizations are to connect learning opportunities and sustain connections as a dynamic learning landscape inevitably evolves. Moreover, the capacity for co-reflection on shared activities is a productive bi-product of relational agency, an idea that relocates the values of DT from a competitive advantage within an education organization to a reciprocity advantage among educational organizations.

18 Level 3: Design Thinking Cycles

The interplay between convergent and divergent thinking also shaped inter-organizational thinking from event to event. At the third level of analysis, we segmented the overall project into its two separate design cycles of inter-organizational DT in order to analyze recurring processes that contribute to the joint work of the collaboratory. Each cycle included the same three, recurring, inter-organizational events featured in the level 2 project-level analysis: critique, test, and workshop. During critiques, graduate students presented brief prototype sketches; Zoo staff and one zoo instructor provided brief commentaries on each successive sketch; then everyone engaged in a reflective discussion on the prototype set that informed a plan for the zoo instructor workshop. The test events involved faculty and zoo staff in phone discussions to review and refine prototype(s) to be featured during instructor workshops. Finally, the workshops provided opportunities for instructors to test prototypes and for collaboratory members to rapidly prototype alternatives together. To further segment both three-event DT cycles, we separated each event into the temporal sequence of activities (16 total activities across 6 events) then described how each activity contributed to our inter-organizational approach to DT.

The level 3 analysis depicted in Figure 3 illustrates two key aspects of our level 3 segmenting. Foremost, dashed-line cells delineate the two design cycles. Within each cycle's cell, the three events in the level 2 analysis—critique, test, and workshop—are now segmented into multiple activities, each described using DT phases. The critique session and cycle 2 workshop additionally feature one activity with sub-activity cells that identify additional structure. For example, the cycle 1 critique

involved an activity described as “test and test-ideate.” This activity involved individual student presentations of 9 prototypes, each illustrated as a sub-activity comprised of paired test and test-ideate sub-cells. Based on this level 3 segmenting, we qualitatively characterized and compared the 16 activities characterize features of cycle activities that support inter-organizational DT. The first feature is within-cycle testing processes. The second is an across-cycles progression of thinking and acting together. Importantly, the within-cycle process contributes to the across-cycle progression and illustrates a novel aspect of inter-organizational contributions to DT.

Within-cycle testing. To begin, the within-cycle process entailed progressive testing across events. The respective prototypes enacted during the cycle 1 and 2 OA camps (see Table 1) reflect testing-based contributions of an increasingly larger and more distributed set of collaboratory members. From the critique to test to workshop events (see Figure 3), each cycle involved more collaboratory members in testing prototypes. This involvement, in part, reflects the intended structure of cycle events. The critique event revolved around sequential testing discussions of each graduate student prototypes (e.g., Figure 5); the test event revolved around testing a single prototype that refined and integrated testing discussions in anticipation of sharing the prototype with instructors at the OA instructor workshop; and the workshop, itself, revolved around interactive testing of the prototype among instructors and graduate students.

By the same token, regardless of the level of involvement, testing and refinement do not guarantee that a prototype alone will enable instructors to facilitate student-centered discussions in every instance. For example, prototyping open-ended question prompts as a tool that facilitates student-centered discussion but nevertheless underspecifies what an instructor should do under the wider range of practical, circumstantial, and social conditions that instructors encounter. For example, an instructor navigates new groups of youth, trying to figure out how to formulate relevant questions and when exactly to ask them during a dynamic, fast-paced camp experience remains a distributed achievement that requires experience. Instructor and graduate student contributions to within-cycle testing processes demonstrate how collaboratory members exercised relational agency to navigate these indeterminacies. By enlisting their individual expertise and prior experience, collaboratory members contributed a personal perspective on prototypes during both cycles. For example, instructors noted that the think-pair-share structure must be adapted when the animal discovery circle (e.g., Figure 4) grows

from the typical size of less than a dozen students to an outsize group of several dozen students. With larger sizes, circling the group with the animal takes more time and precludes stopping to field questions from the youth. Figure 6 below illustrates one animal discovery where instructors successfully shifted youth-instructor discussion patterns.

Most notably, all four youth in the image are paired and engaged in parallel discussions, setting the stage for subsequent sharing. Moreover, whereas youth often raised their hands to vie for instructor recognition during initial OA observations #1-3 (see Figure 4), here the student at the bottom of the image is using her hands to communicate size to nearby peers instead. This illustrative instance is evidence of how a modest refinement to the OA system of teaching and learning like think-pair-share can give rise to non-trivial enhancements to youth experiences. Rather than the limited attention of a single instructor, the participatory dynamics of think-pair-share enable youth to capitalize on the abundant attention of peers. Similarly, insofar as DT inspires and enables participatory processes and practices, contributions from more individuals, and more organizations, can give rise to emergent interactions with the potential to yield noteworthy improvements. As such, testing leveraged diversity across convergent and divergent thinking contributions in the first cycle, both among collaboratory members and among youth in the cycle 1 OA camp, were promising preliminary indicators of collaboratory efforts to exercise relational agency and amplify it across cycles. Cycle 2 activities illustrate this point.

Across-cycles progression of thinking and acting together. Comparing cycles 1 and 2, the within-cycle testing process also gave rise to increasingly substantive contributions and evidence of across-cycle progression. Collaboratory members engaged with multiple contributions, and the contrasting perspectives underlying them, in a substantive process of negotiating prototypes. These negotiations involved high-level ideas about learning through social interaction as well as rapidly refining prototypes in relation to OA experiences. Increased negotiation also marks a shift across cycles, from engagement in testing prototypes towards an exchange of testing perspectives, and is exemplified in the cycle 2 critique and workshop events. We present two examples from the level 3 activities in Figure 3 in order to illustrate this shift.

The first example comes from the cycle 2 critique event, which included a “test” activity with a sequenced discussion of 5 prototypes. Figure 7 below illustrates two of these prototypes. In panels 1a-1c, a three-panel storyboard

Figure 6: Image of circle section from cycle 1 OA observation shows pair discussion as part of think-pair-share structure during an animal discovery activity.

further adapts the think-pair-share structure featured in Figure 5. The adaptation expands the structure from stationary animal discovery activities to mobile hiking activities throughout the zoo campus. Panel 2, meanwhile, proposes an open-ended question that seeks to foster wonder about the animals that students observe during animal discovery activities. These cycle 2 prototypes each make progress on the cycle 1 think-pair-share structure by adapting it for the more dynamic, changing context of a hike and expanding the topic of conversation from curriculum-centric open questions to broader questions around interest-driven wonderings.

Further, these prototypes continued to evolve during as the cycle 2 test activity progressed. The test activity evolved into an unplanned ideate activity as contributions from graduates students, faculty, staff, and an instructor related the prototypes to one another and to the preceding cycle 1 efforts. Through ideation, the collaboratory members conceptualized a cycle 2 “toolbox” of resources intended to support student-centered discussions during camp activities. Whereas the first cycle workshop and OA only employed a subset of first cycle prototypes, the second cycle employed them all in an integrative fashion. The core design of OA camps remained resilient and recognizable as instructors incorporated modest innovations. Meanwhile, the activities themselves progressively resonated with more student-centered

Figure 7: Two graduate student prototype tasks slides presented during Cycle 2 Prototype Critique Session.

discussion patterns. These patterns enhance opportunities for individual contributions, peer exchange, and, thereby, learning. At the same time, discussions were also infused with a modest, but noteworthy, extra-curricular scope through questioning that focused on wonder.

A second, brief example of cross-cycle progression is taken from the cycle 2 workshop. During this event, graduate students and zoo instructors interrogated and further refined the toolbox, self-organizing parallel, collaborative experimentation. Graduate students first presented the toolbox resources then instructors tested them by verbalizing thought experiments as they imagined implementing a tool; groups then rapidly prototyped derivations of the resources, therein co-generating situational variations based on instructor prior experiences. These illustrations of iterative testing illustrate how the interplay between convergent and divergent thinking across two organizations fostered a collective process for integrating prototypes. Across two design cycles, these processes shifted in the degree contributions as more people with more varied roles contributed more often. They also shifted in the kind of contributions because collaboratory member contributions led to more connected and integrated prototypes in comparison to cycle 1.

Together, the within-cycle process and between-cycles progression also suggest that collaboratory members engaged in shared conversations with a situation (i.e., Schön, 1983), namely the OA camp experience. With respect to relational agency, these cycle features demonstrate how inter-organizational contributions can be both creative and integrative. Together, these cycle-level shifts suggest that DT can inspire and enable decentralized and participatory processes that position more individuals and more organizations with exercise agency in relation to one another. In our next level of analysis, we more closely examined three exemplary activities identified based on who contributed, how they contributed, and in relation to what DT practices and tools.

19 Level 4: Design Thinking Activities

To this point, the case analysis has provided accounts of the collaboratory as a whole, the project around which joint work and common focus revolved, and the progressive cycles across which the project evolved. The fourth and final level of analysis considers the moment-

Figure 8: Cycle 1 graduate student prototype for OA scientific experiment activity.

to-moment interactions on which the preceding levels of analysis rest. Said differently, insights gleaned from the preceding levels were not inherent preconditions of inter-organizational events but rather the variable outcomes of the social interactions among collaboratory members and with the youth who attended the five OAs observed across the project. By focusing on social interaction during specific activities, we consider the real-time dynamics among the individuals and organizations participating in the collaboratory. As they engage with prototypes within and across DT cycles, their contributions lend perspective that is increasingly complementary and integrative. The level 4 analysis is represented in Figure 3 in two ways: first, the three activities identified for analysis are shaded activity or sub-activity cells in the level 3 analysis and, second, the segmenting of these activities into episodes appears in the level 4 analysis. We consider each in turn.

The first episode is drawn from the cycle 1 critique (see Figure 3). As one of the first instances of inter-organizational DT, members of both organizations are contributing to a discussion of the cycle 1 graduate student prototype in Figure 8 below. In this episode, the prototype

under consideration proposes to foster interest-driven learning by providing campers with a preview of the three scientific experiments they must choose and conduct.

The proposal includes a concrete, practical previewing strategy in which materials for each experiment are bundled in a bag that can circulate among campers. In response to this storyboard and a verbal summary, the zoo instructor attending the critique event suggested an alternative strategy, as follows:

I can see a kind of adjustment on [what] this is giving them [but] instead of the bag of materials, maybe a laminated sheet with pictures of each item. [...] showing them what each [experiment] entails and that kind of helps them make a more informed decision because the one they want to pursue, they'll dig deeper into it.

Next, a second zoo staff member suggested another alternative: "it could also be an option of stations with materials represented at each station and then the question at each station." This 3-minute succession of contributions is a confluence of testing the student's prototype and ideating alternative prototypes—from bags to laminated images to stations. These suggestions depart

from but recognize the original intention of the prototype. They are adaptations, but resonate with the design goal. In this sense, the episode illustrates divergence from the prototype but not the focus; the discussion remains tuned to the broader, converging focus on supporting interest-driven learning that, in small ways, begin to connect to a larger learning landscape.

In relation to the critique event, the brief episode above is exemplary but also exceptional. That is, none of the 8 other prototypes elicited an integrated set of contributions but, as the across-cycle progression described in the level 3 analysis suggests, this initial episode is a point of comparison with second-cycle contributions in which engagement shifted to substantive exchange.

The second episode we consider is taken from the cycle 2 critique. It is a 21-minute ideate activity that follows immediately after the test activity. Much like cycle 1, collaboratory members reviewed and discussed student-generated prototypes during the text activity but also enlisted the prototypes as a whole set to ideate and co-generate new prototypes as well. Unlike cycle 1, the prototypes were not only a source of engagement; they also served as a foundation for ongoing discussion with the camp-as-situation (Schön, 1983) that led to substantive exchanges. These integrative exchanges also fueled a high-level conceptual discussion about the DT process that illustrates the oscillation between stepping back and moving forward. For example, the camp instructor participating in critique event observed,

‘small changes, smartly made’, it was funny hearing that in the beginning of this whole process, but it’s so true. Like a tiny little tweak you could make to how we present things or what intentions we make, that has a complete impact on the presentation you’re giving, the feedback the kids get, and the connections that they make.

Her observation is a reflection of her own experiential learning. It suggests that the DT process illuminated “what is going on here” in the camp and is consistent with the influence of DT on organizational culture (Elsbach & Stigliani, 2018). Following this high-level discussion, the ideation activity continued to explore two more topics: expanding the scope of the aforementioned “toolbox” from particular camp activities to general camp systems (topic 3); and refining an instructor feedback strategy to support iterative refinements to toolbox resources among instructors as they facilitated each next camp. In comparison to the cycle 1 critique contributions centered on a single, student prototype, this ideate activity illustrates how collaboratory contributions progressed from one DT cycle to the next.

As a final example of this progression, we consider the test-prototype activity in the cycle 2 workshop event. We focus on the sub-activities exploring the four toolbox resources developed during the cycle 2 critique event (see Figure 4). These sub-activities organized student-instructor groups in which a student presented a prototype to support learning then instructors tested the prototype in relation to the prior experiences and expertise. The episode segments featured in Figure 5 illustrate a rapid succession of tests during which an instructor thought out loud about how the prototype might work, or not, then the group responded. Over ten minutes, the small group we analyzed engaged in four verbal tests and rapidly prototyped four variations of the original design. We also noted similar kinds of test-prototype dynamics among other groups, albeit to lesser degrees. These contributions are consistent with the exchanges in previous cycle 2 events but among a more distributed set of collaboratory members. In relation to the across cycle progression, they illustrate a growing capacity in the collaboratory to seek out and provide perspective and insight in relation to a shared conversation with the camp. They also suggest a fruitful intersection between the impact of DT and the reach of relational agency in inter-organizational DT projects.

20 Discussion

Drawing on the insight from the role DT plays within organizations (Elsbach & Stigliani, 2018), our case study considered how members of two collaborating educational organizations contributed to an inter-organizational DT project. In order to ensure that DT is inclusive and participatory, we organized the DT project as an initial contribution to the broader development of a “center without walls,” or collaboratory (Wulf, 1991; NRC, 1993). Our case analysis demonstrated how collaboratory members fostered and exercised relational agency at multiple levels of activity, from month-to-month to moment-to-moment activity. The individual and collective efforts sought to support interest-driven engagement in zoo education programming through rapid mini-cycles of prototyping, testing, and ideating that positioned all members with opportunities to contribute and, equally importantly, to reflect and empathize. In concluding our case study, we briefly consider limitations associated with this project then consider the implications for connecting learning opportunities through collaboratories.

21 Implications for connecting learning opportunities

If each education organization organizes contexts for learning like the OA camp in our case study, then a metropolitan learning landscape of education organizations is a kind of metacontext in which these contexts operate. The immediate experiences and opportunities available through one education organization are not discrete and isolated; they inevitably contribute to or detract from this larger metacontext, but the relationships may be complex. That is, causal connections can be diffuse and the effects of discrete actions in one context on the overall metacontext can be difficult to discern. We acknowledge that our collaboratory project ultimately did not position our joint work as an explicit conversation with metacontextual situations like a metropolitan learning landscape. However, we believe that inter-organizational DT contributes to both the immediate context of zoo education programming and the wider metacontext in which it operates. But how?

Education organizations do not think or act in isolation. As their members think and act with situations, their work intersects wide-ranging stakeholders. Our collaboratory is a basic reflection of this point. As the context of this case points out, our joint work began because university faculty and zoo staff engaged in a conversation with the metacontext in which our respective organizations operate. Our mutual engagement reflects a shared assumption that our organizations operate in relation to this learning landscape. The landscape is not the sum of each organizations' actions but rather a product of their interactions, much like an ecology. Bateson (1978, p. 491) describes ecology as "the study of the interaction and survival of ideas and programs." In order to thrive, an education organization must understand itself and its programs in wider relation to a learning landscape of which it is a part.

By engaging in joint work across organizations, we therefore begin to think and act beyond our organizations. Regularly engaging with the connections an education organization generates, maintains, and destroys--negotiating part-whole relations--also engages organizations in a critical and reflexive understanding of how learning and teaching are organized. Future collaboratory work can grow beyond the two-partner model described in the current study to design minimum viable transformations within their educational contexts and also in relation to wider metacontext of a learning landscape. The prototypes in this study represented the

small changes with the potential to illuminate productive next steps. We believe that a collaboratory can position organizations engaged in DT to pursue these continuous improvements. For example, in relation to a wider range of interventions seeking social transformation, Long (2001, p. 27) observes:

Intervention is an ongoing transformational process that is constantly re-shaped by its own internal organizational and political dynamic and by the specific conditions it encounters or itself creates, including the responses and strategies of local and regional groups who may struggle to define and defend their own social spaces, cultural boundaries and positions within the wider power field.

The joint work of inter-organizational DT involves dynamics and conditions that can reshape organizations and meaningfully influence other organizations. The idea of a learning landscape locates these shaping influences in a relational dynamic that reframes the work of each educational organization as something more than a zero-sum game of winner-enroll-all. It also positions the concept of a learning landscape as ill-defined and ambiguous. In relation to social transformation, Engeström observes that ideas like learning landscapes introduce new challenges.

Complex, consequential concepts are inherently polyvalent, debated, incomplete, and often 'loose.' Different stakeholders produce partial versions of the concept. Thus, the formation and change of concepts involves confrontation and contestation as well as negotiation and blending. (Engeström, 2011, p. 611)

To navigate these value-laden opportunities and challenges, this case study provided preliminary evidence that collaboratories engaging in inter-organizational DT can organize and sustain systems of exchange that cultivate relational agency, thereby laying the groundwork for a shared culture of DT in which empathy and risk-taking give rise to contestation and negotiation, as alluded to in the quote above. We submit that such a culture, developed over time, can support infrastructuring that has the potential for adoption and appropriation; that has the potential for multiplicative effects beyond any one, bounded project to include ongoing socio-technical processes through which multiple organizations might join together; and that afford potential for joining with multiple organizations across a learning landscape and fostering an extra-organizational culture for connecting learning opportunities across a learning landscape.

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