

Maybe a Maker Space? Organizational Learning about Maker Education within a Regional Out-of-School Network

Rafi Santo
Indiana University
rsanto@indiana.edu

Kylie Pepler
Indiana University
kpepler@indiana.edu

Dixie Ching
New York University
dixie@nyu.edu

Christopher Hoadley
New York University
tophe@nyu.edu

ABSTRACT

Maker Education scholarship is accumulating increasingly complex understandings of the kinds of learning associated with maker practices along with principles and pedagogies that support such learning. However, even as large investments are being made to spread maker education, there is little understanding of how organizations that are intended targets of such investments learn to develop new maker related educational programs. Using the framework of Expansive Learning [9], focusing on organizational learning processes resulting in new and unfolding forms of activity, this paper begins to fill this gap through a case study of a community organization serving non-dominant youth that engaged in an 18-month learning process to create its own maker-space. Utilizing interviews, field observations and diverse forms of documentation, findings show that (1) regional organizational networks play infrastructural roles involving *inspiration*, *validation* and *orientation* in expansive learning through providing access to expertise and partnerships, (2) organizational learning around maker education involves dimensions of not only *pedagogy* and *technology* but also of *social geography*, *institutional logics* and *organizational design processes*, and (3) processes of object transformation within expansive learning around maker education by organizations rooted in non-dominant communities can act as sites of critique and, potentially, contributions maker education culture in ways that address issues of broadening participation and increasing equity.

Categories and Subject Descriptors

D.3.0 [Computers and Education]: General

General Terms

Design, Human Factors, Theory

Keywords

Maker spaces, maker movement, expansive learning, non-dominant youth, informal learning, out-of-school time, organizational learning, equity, broadening participation, co-design, participatory design, organizational networks, innovation networks

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee.

FabLearn 2015, September 26-27, 2010, Stanford, California, United States.

Copyright belongs to authors.

1. INTRODUCTION

As the maker movement broadens its reach and shifts from a bricolage of loosely affiliated DIY communities to a focus of educational practice and policy, important questions are emerging about the nature of learning, pedagogy, and organizational innovation linked to maker initiatives. Scholarship to date has focused largely on these issues of youth learning and educator pedagogy, but questions existing at the level of organizations and broader professional networks they exist in remain unaddressed. This study attempts to elevate such questions within the scholarship of maker education as ones that are increasingly critical to answer as investments are being made to bring maker education to new learning environments stewarded by organizations with little historical linkage to the maker movement.

Using the framework of Expansive Learning [9] that focuses on organizational learning processes resulting in new forms of activity, this paper begins to fill this gap through a case study of a community organization serving non-dominant youth that engaged in an 18 month learning process to create its own maker space. Utilizing interviews, field observation and organizational documentation, findings show that (1) regional organizational networks play infrastructural roles involving *inspiration*, *validation* and *orientation* in expansive learning through providing access to expertise and partnerships, (2) organizational learning around maker education involves dimensions of not only pedagogy and technology but also of social geography, institutional logics and organizational design processes, and (3) processes of object transformation within expansive learning around maker education by organizations rooted in non-dominant communities can act as sites of critique and, potentially, contributions maker education culture in ways that address issues of broadening participation and increasing equity.

The results of this study have relevance to organizations, such as schools and informal learning environments, that are interested in learning about maker education, to scholars investigating organizational capacity and development around maker learning and finally to field-building actors and policy makers interested in supporting the circulation of these pedagogies.

2. MAKER EDUCATION SCHOLARSHIP: A FOCUS ON YOUTH LEARNING & PEDAGOGY

As interest in the area from the general public, educational practitioners and policy makers has increased [1], scholarship around maker education has also deepened and expanded. Broadly, research has focused on two primary areas: *issues of youth learning* associated with making and *issues of pedagogy and learning design* associated with supporting making. A limited number of studies, however, have begun to investigate how educational organizations engage in maker education and

attendant issues of implementation, professional development and organizational learning.

Studies of youth learning and making have addressed issues including what the core practices of making entail [3], how they support particular forms of identity development [23], connections to disciplinary areas such as STEM [21] and the arts [19], and distinctions between making, tinkering, design and play [12]. Such studies and many more related to these areas provide understanding of how making intersects with broader issues and concerns of education and the kinds of learning it enables.

Building on this primary area of understanding the relationship between learning and making is a second area of scholarship addressing issues of pedagogical design and practice within maker education. As examples, Gutwill et al. [10] identify particularly productive facilitation moves that educators make within the Exploratorium's Tinkering Studio, Vossoughi et al. [25] attend to the specific forms of pedagogical talk and gesture used by educators in after-school tinkering settings, Peppler [19] examines the importance of helping young makers document their work as part of the learning process, and a number of scholars have investigated the ways that educators learn to become competent and develop identities around maker activities [2,4,20]. This area represents an expansion of scholarship from considerations of the relationship between making and learning to ones of how to support these forms of learning through pedagogy and learning design.

A more emergent and somewhat understudied area of maker education concerns the ways that educational organizations create and implement programs linked to this domain. Wardrip and Brahm [27,28] contrast how two schools implemented maker programs in terms of the structuring and availability of tools, connections made to various subject areas and how professional development was structured for teachers. McKay and Peppler [16] explore the possibilities of mobile 'maker carts' to support maker activities within a school. Sheridan et al. [23] contrast three maker spaces in terms of how their distinctive organizational contexts afford different participation norms and the learning opportunities available to those that participate. None, however, investigate how meso-level dynamics at the level of inter-organizational networks and structuration of professional fields.

As further investments are made into spreading maker education into new contexts [5,6,17], we argue that studies of maker education that are conducted at the level of the organization and broader networks they are situated in are increasingly critical as a means of understanding how new actors are experiencing this space, what issues they face as they create maker programs and what they can offer the broader field in terms of how maker education programs and practices might evolve as they move to new contexts. This study aims to advance what we know vis-à-vis such concerns.

3. EXPANSIVE LEARNING AS A FRAMEWORK FOR UNDERSTANDING ORGANIZATIONAL EXPLORATION OF MAKER EDUCATION

For this investigation, we employ the framework of Expansive Learning [9], rooted in the broader tradition of Cultural-Historical Activity Theory [7]. Expansive learning aims to understand how new ideas, practices and technologies are developed based on a process of looking at current problems and tensions found in a context. The language of 'expansion' is both evocative and useful

to focus on here – rather than learning by 'practicing', 'constructing' or 'appropriating', learning is achieved by expanding from a current 'knowledge location' and building outwards on the basis of that knowledge while simultaneously solving tensions inherent in it to create previously non-existent knowledge. This focus on the generation of the 'new' distinguishes expansive learning from the prevailing metaphors of learning, namely acquisition and participation [22]. It is a particularly useful lens for looking at issues of organizational learning, processes where there is no pre-determined 'answer' that someone involved in the context possesses, and both the problem and solution are clarified and created along the way.

In the Expansive Learning process we investigate here, analytic attention is given in particular to three constructs: the *object* that is the focus of the learning process, the *division of labor* across the actors involved in learning and the role of *community*. The object acts as the focus of the collective activity associated with Expansive Learning; it is at once the goal being moved towards but also itself unstable, ambiguous and a site of sense-making and transformation. In short, the object itself becomes better known, and even, transforms, within an expansive learning process. In the study we trace the transformation of the object of creating a maker space and the ways that understandings and conceptions of this object shift over the course of the expansive learning process. In looking at the role of community, we seek to understand how participation in a formal network of organizations plays a role in expansive learning, and how inter-organizational division of labor (supportive social relationships, formal or informal, existing between organizations) mediate our focal organization's learning process and the associated object.

4. CONTEXT OF INVESTIGATION – BROOKLYN NEIGHBORHOOD CENTER

This study focuses on the Brooklyn Neighborhood Center (BNC)¹, a community-based organization (CBO) linked to a local college that serves youth from non-dominant communities. The site was purposively selected for two reasons consequential to the possibility of theoretical contribution to maker education. First, it was an organization new to ideas of maker education and thus provided the opportunity to understand how learning about this domain could unfold. Second, it serves a demographic of non-dominant youth that are often the focus of concern vis-à-vis access to maker education programs.

Central to the organization is its drop-in center, the Creativity and Collaboration Space (CCS), a 6,900 square foot converted gym space that houses programs ranging from sports and music production to social activism, arts and college guidance. Teaching artists and youth development workers facilitate these loosely structured activities, and the drop-in center's norms are such that teens often come and go from activity to activity, or simply hang out and socialize. Though adults actively encourage participation in the varied offerings, the philosophy of the organization is rooted in an assumption of creating a safe space that supports relationship building and youth self-determination above any given activity it might be offering. This orientation is linked to BNC's roots in paradigms of socio-emotional learning and positive youth development, both of which are traced back to the organization's origins in the college's psychology department.

¹ All organization names in this manuscript are pseudonyms.

For this analysis, the research team studied BNC over 18 months, from mid 2013 to early 2015. During this period BNC became a formal member of a regional educational network, the Mozilla Hive NYC Learning Network, a collective of youth-serving organizations that collaboratively create digital media programs that align with production-focused and interest-driven pedagogies [13]. While BNC and its staff form the focus of study, its participation in Hive NYC provides an important backdrop. As we'll show, participation in Hive, among other factors, contributed to an organizational decision to create a maker space within its CCS drop-in center and engagement in a wide range of activities associated with pursuing this idea. The period of investigation culminates in summer of 2014 with a two-week, intensive co-design process of the organization's 'maker lab'² (as it was referred to), which involved youth leaders, organization staff and outside expert organizations coming together to learn about maker culture, technologies and practices and developing initial ideas for what would be included in BNC's 'maker lab'. These three events, initiation into and participation in the network, the decision to explore creating a maker space and the expansive learning activities BNC engaged in, and the co-design of the maker space form the backbone of the activities analyzed here.

5. METHODS

Taking a case study approach [24], this investigation integrates diverse qualitative data in order to establish an in-depth picture of BNC's activity over the 18-month period of study. A central data source is 13 semi-structured interviews with BNC staff averaging about one hour each. Tom, BNC's deputy director, is the primary respondent, with other staff, and sometimes, collaborators, included. Additional data include approximately 50 hours of field observations that occurred at the CCS drop-in center during programming, at meetings that BNC staff had with collaborators, and at Hive network events as well as at numerous conferences that BNC staff participated in. Finally, various forms of organizational documentation were included in our analysis: grant proposals, meeting notes and publicly available documents such as blog posts, videos, photos and reports the organization created to capture and share its work.

The study focuses on answering the following questions about how expansive learning plays out for organizations as they explore maker pedagogies:

- *What roles do social ties with expert organizations and membership in broader regional networks play as organizations engage in expansive learning about maker pedagogies?*
- *What forms of knowledge about maker education are encountered during the expansive learning process?*
- *How can a local expansive learning process act as a site of critique and contribution to broader, field level conversations around maker pedagogies?*

Analysis follows two approaches taken within Expansive Learning literature. The first, offered by Engeström [8] focuses on questions of why learning is occurring, who is involved, how it occurs and what is learned, an approach framing our first two questions. The second approach, linked to our third question, involves tracing the ways that the object of expansive learning

² Throughout the manuscript, we use the term 'maker space', except in transcripts where study participants alternate between 'maker space' and 'maker lab'.

undergoes qualitative 'turning points' [14] and itself experiences expansion to include new facets.

6. FINDINGS

6.1 Participation In An Expertise-Rich Network: Inspiration, Validation And Orientation

As it is central to the organization's expansive learning process around creating a maker space, we begin with BNC's entry into and participation in Hive NYC, a regional network of informal learning organizations. It was within Hive NYC that BNC was formally introduced to the maker movement broadly, to its pedagogical possibilities specifically, and critically, to a group of expert organizations around the city that were leaders in this space. These actors and the broader network allow us insight into the *division of labor* and *community* that supported the expansive learning process. These expert organizations, as well as a number of experiences and opportunities associated with being part of the network, provided *inspiration*, *validation*, and *orientation* during BNC's learning process; (1) they positively positioned the organization and its learning environment as a viable site of maker culture and pedagogy (inspiration), they provided what might be considered "low level" program collaborations that took place at the CCS center that both (2) validated early inclinations to experiment with maker pedagogies (validation) and (3) oriented both BNC staff and youth leaders to maker practices in a way that would support the eventual collaborative design of the maker space (orientation).

6.1.1 Networks as a Source of Inspiration and Positive Positioning for Engagement in Maker Pedagogies

Tom, BNC's deputy director, traces the moment when he first considered creating a maker space at CCS to a visit in early summer 2013 by a staffer deeply steeped in maker education from a new partner organization, the Sync Institute, that he had become connected to at a Hive meet-up. We asked him about this moment:

Researcher: Could you just like, map me to the beginning? When did this sort of spark for you?

Tom: About building a maker space? I'm trying to think... It might have been when Shannon came to visit. I think I had an inkling before that. [...] She came out for a visit... [...] I think she just said, "This would be a great maker lab!". And it was like, 'ding!' This would be, you know? I just love the space as a kind of experimental lab for anything.

This kind of external encouragement over time contributed to Tom more fully, if still somewhat tentatively, orientating to the possibility of a maker space in CCS. In an interaction with a member of our research team in the late summer 2013, while giving an informal tour of the CCS space, Tom commented, and to some degree, sought positive feedback about the possibility of a maker space at CCS:

Tom: <walking around CCS> Don't you think it would be great for a maker lab?

Researcher: It would be great, it would be excellent.

Tom: If you have any ideas or feedback on how we can do that - I mean, to me, it's like just start setting up the 3-D printers and the laser cutters...

Researcher: Yeah, all you need is some equipment, some roaming guides, and you're set.

Tom: Yeah, it's ideal.

The off-hand nature of the comment “Don’t you think it would be great for a maker lab?” signals new ownership of a still somewhat abstract idea of having a maker space, and a positive orientation towards it. At the same time, Tom clearly signals that he is new to this domain – he actively looks for advice (“if you have any feedback”) and indicates a somewhat technology-centered orientation towards what a maker space is, one that organically evolves, as we note later, into more complex conceptions.

During this period of the fall of 2013, BNC’s membership in Hive NYC also led to participation in the New York City Maker Faire, an event that is later recounted as consequential in the organization’s sense-making around maker culture and how it fit in with BNC’s values. In an interview following the event, Tom shares about the organization’s experience with Maker Faire, which he recounts as initially one of being somewhat tentative about participating in the event due to self-perceived lack of technological fluency but which shifted to eventual excitement after a well-received activity by the young people at the event:

BNC wanted to contribute and I was like sure, what can we do? We're not really tech oriented. And then Caitlin [from Hive] said, "Oh don't worry about it, just do something cool. Just propose something." So we proposed "repurposing stuffed animals". [...] Marielle, who's one of our site directors and was a teaching artist, did a project where you get all these stuffed animal parts, and then you teach kids how to sew by reanimating some stuffed animals. [...] They loved it. They went nuts. We had basically 30 kids, probably, we attracted. We went through stuffed animals in 90 minutes - we were supposed to be there for three hours, we brought tons of stuff. They just couldn't get enough; it was like sharks.

As with the other instances shared above, the Maker Faire example is one of positive positioning of BNC by external actors it was coming into contact with through this formal professional community that valued and contained expertise around maker pedagogies. BNC being externally positioned on numerous occasions as a viable actor in the domain, even if it saw itself as lacking expertise, played an important role catalyzing a larger expansive learning process around maker education within the organization.

6.1.2 ‘Low Level’ Collaborations as Sites of Collective Organizational Orientation Towards and Validation of Maker Pedagogies

The experience of positive positioning and inspiration shared above overlapped with and was followed by another period of what can be seen as ‘low level’ collaborations between BNC and organizations more experienced with maker education. In one case, BNC acted as an implementation site for a maker-oriented physical computing program developed by the Sync Institute, with Sync staffers running the program at CCS and BNC providing the space and participants. In another, BNC adopted an ‘off-the-shelf’ pre-existing curriculum called Tech Crew from the TECHform organization, another member of the Hive network.

These two collaborations, neither of which involved BNC itself designing maker-oriented educational programming but rather inviting existing programs into its space, played two important roles in its expansive learning process: the collaborations (1) collectively oriented and instilled agency in a broader range of organizational actors, both frontline staff and youth leaders, to maker practices and technologies and (2) validated inclinations on the part of organizational leaders to continue engaging with this new domain and the associated learning process around it.

The initiation of the first collaboration with the Sync Institute happened almost immediately when BNC joined the Hive community. At that point, it was unclear whether acting as an

implementation site for the Sync Institute’s program was intentionally linked to a process of learning about maker education or simply a matter of bringing unique programming into BNC’s space that it wouldn’t have access to otherwise, or both. The decision to collaborate with TECHform, however, was more clearly linked to exploring maker pedagogies. At the start of 2014, Tom shares about his decision to implement the Tech Crew curriculum, something the organization usually wouldn’t opt to do but which he saw as part of a larger learning process moving towards creating a maker space:

"We're going to join TECHform to revive our ailing computer lab at BNC which has eMacs and old PCs. And now that we have money, we're going to get new computers, but we also thought: hey, let's activate and mobilize our geeks and really put them to task and let's just join TECHform and do their curriculum. We don't usually do these pre-made curriculum-based programs, but I felt like, in this case, it would be really cool. [...] I think that would be a great bridge to developing the Maker Space and building up the lab."

As part of adopting the TECHform curriculum, BNC hired a new staff member responsible for running the program, and the curriculum involved youth taking on leadership roles vis-à-vis technology in the organization; they were to both engage in digital making as well as act as tech help to assist in repairs and upgrades of CCS’s computer lab.

A couple of months later, Tom shared how these two collaborations were playing out, how they helped to start build somewhat of a ‘maker’ orientation among BNC youth, and how they ended up, for him, validating the inclinations around exploring maker practices and technologies. Speaking about seeing the first implementation of the Sync Institute’s PhysComp Tinkering program at CCS, he shared:

"It was phenomenal. [...] I hooked up with them right away and so it's been in the back of my mind. Like, what the hell is the PhysComp Tinkering program anyway? What did we sign up for? And I loved it! I loved it! Kids were taking apart consumer electronics and I was so excited about it, putting on these goggles and gloves and using the tools and then making cool, STEAM stuff; invisible hands and space guns and really cool [stuff]. And with the BNC vibe, with kids coming in and out, reggae music playing really loud... It was like, oh my god, it works! The kids had experience with TECHform leading up to it and it was this level of focus and structure that I think they got out of just being a part of TECHform. [...] To me, Rafi honestly, it was perfect. It was another validation of what I want to do."

In recounting his experience and perception of the Sync Institute’s program being implemented at CCS, Tom links things that he saw as novel (particular types of practices and usages of technologies – “STEAM stuff”, “invisible hands”, etc.) with the organization’s existing culture (“the BNC vibe”, “kids coming in and out”, “reggae music playing really loud”) and the alignment and fit between the two (“Oh my god, it works!”). As Tom put it, the experience was “another validation” of the broader project of creating a maker space at CCS.

While these collaborations served as validation, they also helped build collective orientation, interest and agency around maker culture for the front-line educators and youth leaders of BNC. As Tom noted above, the collaboration with TECHform played into preparing his youth for the PhysComp Tinkering program in terms of the ability to engage deeply (“this level of focus and structure that I think they got out of just being a part of TECHform”). Later, in mid-summer of 2014 immediately prior to the maker space co-design retreat, Tom again drew a line between participation in these collaborations and the ability of his youth leaders to engage substantively in thinking about the BNC maker space:

What I want the students to get is a sense of, first of all I want their creativity and energy and their incredible insights to not just contribute but dictate the process. I've taken great care to get TECHform, we sort of really opened up a path for our nerd community to come out and we're really excited about that and those kids are going to be heavily involved. [...] And yeah, we hope that they'll take the lead. They're pretty comfortable with us by now; a lot of them are helping with the PhysComp Tinkering summer program, so it's going to be a natural bridge for them to go from TECHform in the spring to PhysComp Tinkering in the summer to creating [the] maker space in August.

As noted earlier, some decisions related to collaborations with organizations more fluent in maker pedagogies may have been more or less intentional than others in terms of an explicit organizational learning process, but in looking back on those choices BNC leadership saw them as foundational in a number of ways. Directly observing collaboration-linked programs validated early inclinations and efforts, and participation in these programs oriented a broader range of organizational stakeholders to the process of organizational learning around maker education.

6.2 Dimensions of Organizational Learning around Maker Education

In following BNC's process of exploring maker education, it became clear that there were many dimensions associated with this domain that the organization was learning about. Rather than accounting for the specific ideas around maker education they encountered, as this is an unstable and evolving knowledge-base, we offer here a simple framework that covers the general areas that the organization learned about that we might expect to be somewhat stable across organizations and even as the field of maker education evolves. In this section we share how the organization learned not only about issues of (1) *pedagogy* and (2) *technology*, which might be expected as central dimensions of learning around maker education practice, but also issues of (3) *social geography*, (4) *institutional logics* and finally (5) *organizational design processes*.

A visit that Tom and Gloria, another BNC leader, made to the St. Augustine School maker space, located in a New York City private school, evidences these varied dimensions of learning about maker education, and we will refer to the visit throughout this section, adding data from other points in the case study as well.

6.2.1 Technology & Pedagogy

We discuss these two dimensions of organizational learning together because they were deeply intertwined within the conversation at St. Augustine, something that aligns with progressive orientations towards the role of technology in learning environments.

During the visit, Tom and Gloria spoke with Ben, who runs the school's maker space. In sharing about the 3D printers that he had in the lab, Ben advised avoiding what he'd come to see as a common dynamic of kids downloading 3D model files from the popular website Thingiverse, something that resulted in long lines of students printing out small objects, but, in his view, not learning very much in doing so and simultaneously creating logistical challenges around usage of the limited number of machines available.

Other points in the conversation more squarely focused on issues of pedagogy, with Gloria and Tom inquiring about Ben's approach to how much free-choice versus direct instruction he provided. He shared about how this dynamic evolved over time for him:

The first year we had a curriculum where everyone was doing the same thing, basic arduino. But then I found kids had trouble coming up with their own projects. In the 2nd year, instead of dissociated activities, it was project based, make a nightlight. But kids were disengaged. This year I presented them with a menu of possible projects. I really wanted things that were well documented online, so students could self direct.

The conversation continued along these lines for the greater part of the visit, touching on ideas about how making might connect to various traditional disciplines such as science, math and the arts, technical issues and advice around various kinds of technologies and how they played out pedagogically, and how different demographics of students varied in how they engaged with the space.

6.2.2 Social Geography

Another dimension of the learning BNC engaged in is what we term the *social geography* of maker education as an emerging field: the people and organizations that could be consequential to an organizations' learning process as sources of inspiration, advice and collaboration. During their visit with Ben, these connections were rarely a direct subject of conversation in the way that technology and pedagogy were, but rather emerged organically throughout. Ben mentioned another maker space in a college in the city as "the lab that you have to see", and discusses another organization he'd worked at in the South Bronx in the context of the models they employed working with non-dominant youth around maker education. Of course, the visit to the St. Augustine space and discussion with Ben was one of many that resulted from knowledge previously gained by Tom and Gloria about the loosely connected social geography of maker education, in particular regarding the local actors in the NYC region. Conversations relating to this dimension of learning, while perhaps not often as conceptually complex as some of the conversations around pedagogy and technology, were clearly critical in that they established the possibility of those more conceptual and 'content' focused discussions to occur, and for substantive partnerships to emerge that supported BNC's exploration.

6.2.3 Institutional Logics

In ways that were similar to learning about social geography, understandings of institutional logics, in which we include issues of funding, politics and power related to the domain, were another dimension of learning that we observed BNC engaging in. This form of learning was sometimes straightforward, such as receiving information about new funding calls or particular funding agencies that BNC might keep their eye on to support this emerging work. Others were more nuanced, as was the case during the visit to St. Augustine, where the conversation seamlessly flowed from a discussion about the usage of 3D printers in the space to how these technologies were perceived by powerful stakeholders, with Tom asking if the printers were 'a draw' for funders, and Ben stating that they definitely were. Gloria followed up with asking about how parents perceived them, and Ben sharing that "Oh yeah, there's milking it on those tours. It's fine." and that sometimes the school administrators just referred to the maker space as "where the 3D printers are."

As with issues of social geography, the dimension of learning about institutional logics can be taken for granted for those that regularly occupy positions of organizational decision-making. We offer they are especially consequential to keep in mind here though in discussing organizational learning around maker education. In an emerging, and in some ways not traditionally institutionalized and organized field, such forms of knowledge

and the manners through which they're made accessible deeply mediate organizational decisions to engage with these practices and technologies.

6.2.4 Organizational Design Processes

The final dimension of learning we observed relates to the design process itself that BNC could develop in order to create a maker space. In a way this existed as a sort of meta-dimension, the 'learning about learning' that was figured out as the organization moved deeper into the process and closer to creating something substantive on the ground that was of its own design. Reflecting immediately after the St. Augustine visit, Tom stated that the thing that struck him most in hearing about Ben's experience was the importance of giving attention and consideration to the organization's design process around a maker space and who was at the table during that process:

The first thing that comes to mind for me is the iterative design process. He's really suggesting just get a couple of things and then see how that goes. Don't, you know, build a huge lab and then see what happens. Take it a step at a time. [...] And then the second thing I think was to get the community involved. I really liked what he said at the end rather than build it and let the community come. I think in our circumstances, it's really critical to do it with the community and it's important to make those decisions about, you know, who the community is and why the community needs it and to again do it with people you've already established as a community.

While this reflection is of course occurring in a moment when BNC has already made a range of decisions about how the organization will go about the process of organizational learning towards and creation of a maker space, this speaks to the fact that such processes unfold dynamically and are themselves subject to shifts as new knowledge is encountered. In short, during expansive learning one is also figuring out how to structure the learning process in a way that is tailored and localized to the particular issues and ideas one is learning about.

The long time-scales that can be involved in organizational learning processes around new domains allow for reflection about key issues, and the issue of how the space will get designed is certainly a central one to be grappled with for many if not all organizations that engage with maker education practices. This point of how to structure the design process around the maker lab comes up a number of times during the exploratory phase BNC engaged in, and is something that we will explore more fully in the next section.

6.3 Organizational Learning as Site of Maker Culture Critique and Generation of Solutions for Broadening Equity & Participation

"Why not just hire an individual and give him/her a budget and say: "go for it!"? Why co-design a maker space with a community of 15 high school students, 1 college student, 15 BNC staff, a team of professional makers, graphic designers and learning designers, and a jazz musician/social worker/architecture professor with lavender hair?"

— How to Co-Design a Maker Space, BNC produced Tumblr site, 2014

While up to this point we have focused on how an organization learned about maker education from a broader field of actors and within a regional professional network, in our final analysis we invert the analytic focus to look at how a local organizational learning process might result in contributions to and transformations of the broader ideas, values and practices associated with maker education. We share how local sense-

making that occurred around maker culture resulted in BNC critiquing practices it was seeing in the field and making principled decisions specifically around how its maker space would be designed and who would be involved. These were decisions that it would come to see as potential contributions to maker education on how to resolve issues of equity and broadening participation.

We draw here on a number of key assumptions put forth by expansive learning theory that we describe in brief. Expansive learning is described as collective movement towards an 'object'; the "raw material" or "problem space" of activity. The object simultaneously plays a "focal role" but is also "inherently ambiguous", and is "an invitation to interpretation, personal sense making" [9]. As such, the object must inherently undergo transformation as the learning process unfolds, with that ambiguity eventually yielding to greater clarity concerning what problem is being solved as well as how to solve it. Finally, the object is understood to exist on two levels: at the local and subjective level for the actors engaged in a particular activity system and associated expansive learning process, and on a general, societal level, a level which undergoes historic transformation based on aggregated results of localized expansive learning processes.

Here, we interpret the general, societal object as 'maker education' and the technologies, practices and learning arrangements associated with this loosely configured set of ideas. The local object for BNC is the broadly conceived idea of having a maker space, an object the organization is continually moving towards and refining as it engages in its process of expansive learning, and that undergoes qualitative "turning points" over time [14]. We argue that BNC's process of moving back and forth between the general, societal object of maker education and the evolving local object of creating a maker space created the conditions for critique and contribution to the societal object of maker education. We trace the roots and evolution of the local object in relation to the societal object to show how this unfolded.

6.3.1 An Ambiguous Object: "Don't you think this would be a great maker space?"

We look back here to interactions shared earlier in which BNC was positioned by outside actors as a viable context for a maker space, interpreting these early interactions as ones in which BNC staff had a limited understanding of the societal object - maker spaces, technologies and pedagogies - and as a result the local object - a BNC maker space - was similarly ambiguous ("it's like just start setting up the 3-D printers and the laser cutters..."), but enough to spark direction for a learning process oriented towards this diffuse set of ideas. At times, this ambiguity concerning the local object would reveal that BNC's conceptions of the broader set of ideas around maker learning were deepening. At one point, Tom noted:

"I think the question keeps coming up too, what is a maker lab, when do you have a maker lab? So you have a computer lab, is it a maker lab? No. You get a 3-D printer. Is it a maker lab? Maybe."

Statements like these point to a productive kind of questioning of what the 'it' is that's being pursued through the expansive learning process, and we found that these preceded moments of clarification around what specifically were distinctive frames and ideas within maker education that BNC felt were important to grapple with, as we explore in the next section.

6.3.2 Specifying the Object, Sense-making with Existing Organizational Practices

At a later point in the process, Tom hooks onto the practice of ‘design thinking’ as something clearer within maker education and pedagogically distinct from his organization’s current practices, something that to a degree specifies the object for him and provides a sharper sense of what sort of learning might need to go on within the organization:

“Here’s what I want to do. I want to infuse the staff, really the professional development in a sense, with design thinking. Because I want to move toward design thinking for our organization because I feel like design is a metaphor for change that is incredibly empowering. [...] I keep thinking [about] this notion – Ok, I can’t change my life; it’s always the same. That’s what a lot of our kids are like – nothing changes. I live in fear; I go to school here, etc. I feel like maybe you can redesign it. Maybe you can design it differently. And here are all these great tools that are going to allow you to sketch it out – what it might look like – and that is really exciting to me. [...] I want CCS to become a place where if it’s not central it’s very high on the agenda – design thinking, design education. And I think that’s also good in terms of technology and bringing [in] STEM. I think we’re moving a little bit into STEM and I think design is probably where to go for us. It makes a hell of a lot of sense.”

At the same time as these aspects of the object are becoming specified as BNC focuses in on broader ideas, like design thinking, related to maker education, the staff are simultaneously aiming to make sense of these ideas in relation to the organization’s existing practices, aiming to establish familiarity within these new objects. Recalling an instance when he and some other BNC staff participated in a maker workshop offered by another organization as professional development, Tom comments on how the experience aligned with existing norms of BNC:

“It was great. I really enjoyed it. We did aerial photography and we built a rocket. And it was fun, and it just felt incredibly familiar, in the sense that we’re hands-on, we like people who tell us some basic principles and then let us do it ourselves, you know, yet are there. And that’s kind of how we facilitate our workshops.”

6.3.3 Questioning the Societal Object and Creating Solutions in a Localized Object

As certain things about the generalized, societal level object of maker education became more clear, less ambiguous, and were increasingly localized through a sense-making process, Tom also came to see issues and potential critiques of the generalized object of maker education:

I’m really interested in this question of like, you know, are Maker Labs racialized on any level? [...] Again, of course we already know the answer to that one, but then how can we not really critique that and then change the way that they’re designed, not taking anything away from the colleagues that we’ve met.[...] In the design process, who are the designers of the labs? Who are the designers of the curriculum?

In noting this issue of who is at the table in the design of maker spaces, and perhaps maker culture, Tom echoed broader critiques of the maker movement that were emerging during this general period of time broadly linked to parallel issues of who participates in STEM fields. He also framed the critique in a way that speaks to traditions of radical educators, as a question of who decides how learning environments should be designed. As Tom articulated these critiques, he also came across others that he saw as making similar arguments and validating his inclination to foster an equitable design environment for BNC’s maker space, as in this example where he notes a conference panel that felt particularly consequential to him:

“The Maker Space panel made me feel like there is definitely a place for this kind of social/emotional design thinking and that it’s just not

developed yet. That made me really excited, frankly, that there’s this whole space that needs to be opened up. [...] It also made me feel like, just in terms of authorship of design and leadership in designing these spaces that people of color have to be involved in designing these spaces. That’s also critical.”

BNC’s question of who is at the table when these spaces are designed eventually led into the decision to spend substantial resources on an intensive collaborative design process lasting two weeks, bringing together BNC youth leaders, staff, and experts from a number of the organizations with which BNC had established ties. A couple of weeks before the maker space co-design retreat, in mid-summer 2014, Tom shared the following thoughts, indicating both an assuredness in his decision but also a sense that he was going against the norms of how the other maker spaces he’d seen had been designed:

I feel like my experience in the past has been with large art projects that I’ve done. We get great people together in these positions and give them roles and responsibilities and then create a brave atmosphere – an incubator or whatever you want to call it – good things are going to happen. And that’s what I feel like I’m doing with this maker lab. And I feel like I’m a little nervous that a lot of the spaces I’ve seen have been the result of one person really designing it and creating it and creating everything in it. So I’m a little nervous, like, “Well, maybe that is the best way to go. That’s what everyone’s done before that I’ve talked to for the most part.” [...] But I just know our organization; I know our space; I know our people; I know the kids. And this is the only way to go.

Tom lands at a place where he’s found a specific local object – creating a maker lab through a participatory design process – that expands that object in a number of critical ways that have been previously noted as modes of object transformation in expansive learning processes [8,11] the object expands socio-spatially (who’s involved in the collective activity around the object) and also expands morally-ideologically (who is responsible for activity and who is making decisions).

6.3.4 Engaging in Theoretical Contribution to the Societal Object of Maker Education

These shifts in how BNC thought about what it means to engage in maker education and how it would create its own maker lab through a co-design process eventually led to the organization deciding to publically share the approach it arrived at with the larger field. In the language of expansive learning, the organization decided that, based on its own learning process, it could make the theoretical contribution to the societal object in way that expanded how that broader object was conceived.

In a tool titled *How to Co-design a Maker Space*, BNC publically documented what it learned about engaging in such a process. The tool explored how youth, staff and consulting expert organizations worked together to learn about specific tools and technologies, brainstormed what kind of activities they wanted to go on in the space, collectively developed a set of ‘maker manifestos’ that outlined principles and visions for what the space should support, and created physical models of the re-imagined CCS space.

In publically documenting their model of how to create a maker space in an equitable fashion, BNC contributed to an emerging genre within maker education that includes things like the *Makerspace Playbook* [15], the *Maker Club Playbook* [29] and *A Blueprint: Maker Programs for Youth* [18]. This genre is practically oriented - addressing around issues of creating learning spaces and activities that embody values from the maker movement and giving considerations around everything from tools and equipment to the role of ‘maker coaches’ and questions of sustainability. In creating *How to Co-design A Makerspace*

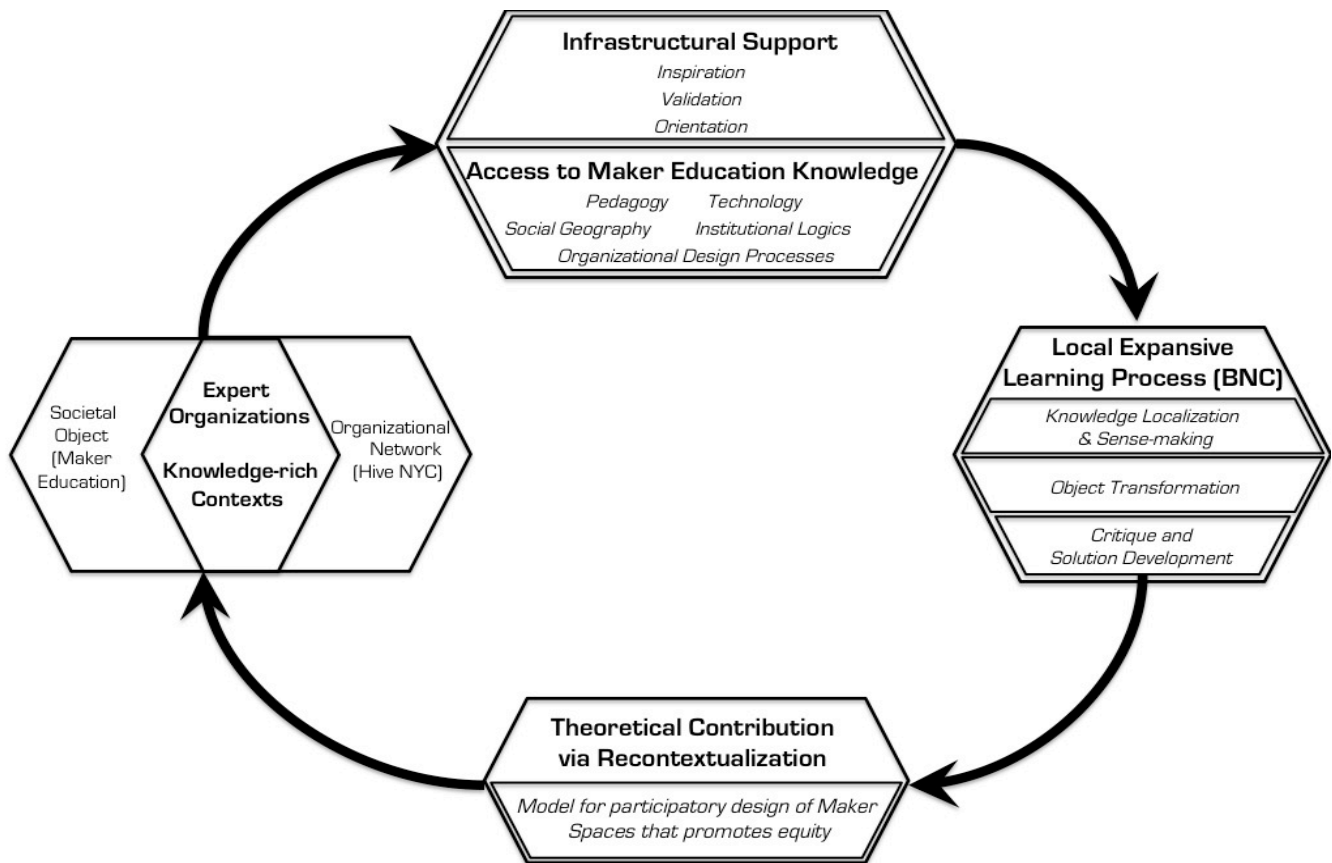


Figure 1. Conceptual model of the relationship between the local expansive learning process at BNC with the broader Hive network and field of maker education.

BNC contributed to an existing genre within maker education, but provided what it saw as a perspective missing from the broader conversation in terms of how educational maker spaces are designed and who is involved.

We argue that BNC showed the potential for organizations that are somewhat new to maker education but that serve non-dominant populations to make contributions to this domain based on insights generated through the process of organizational learning. Rather than viewing the circulation of ideas and practices associated with maker education as a top down, unidirectional one solely characterized by replication or adaptation of models created by existing experts by those with ‘less capacity’, we believe this case shows how multi-directional flows of information between actors from distinct cultural locations can inform and strengthen a broader knowledge base in the field of maker education. We find that when these ideas travel to new learning environments that serve those who often have least access, the attendant organizational learning processes can act as critical sites of remix and reinvention that can help the maker education field better consider how to broaden participation and increase equity.

7. DISCUSSION & CONCLUSION

In this study we describe and analyze the expansive learning process that an informal education organization engaged in as it went about creating a maker space. We show that participation in educational networks plays an important infrastructural role in

inspiring, validating and orienting towards maker education, that the forms of knowledge about maker education encountered are diverse, and that the very process of a new organization coming to understand maker education can be the basis for critique and contribution to the broader field vis-à-vis issues of access and equity. While for the purposes of analysis we separated different aspects of BNC’s learning process, on the ground the role of networks, the forms of knowledge encountered and process of sense-making and critique were deeply intertwined (*figure 1*). And while in some ways BNC represents a distinctive case in that it was able to fairly quickly access expertise and resources related to maker education due its participation in the Hive network, the fact that it was able to do so shows the importance of such infrastructural support and how such opportunities for learning and sense-making are structured in a somewhat new and loosely organized field. More broadly, the case is consequential in that BNC in many ways represents the kind of learning organization that many hope will engage in maker education – one that is relatively new to its ideas, but sees the possibilities of both learning from and giving knowledge back based on authentic engagement with these ideas within its own learning community.

8. ACKNOWLEDGMENTS

This research was funded with generous support from the Hive Digital Media and Learning Fund at the New York Community Trust. Deep appreciation goes to the staff and youth of our focal organization for being open to sharing how they were learning as they were learning.

9. REFERENCES

- [1] Bevan, B., Gutwill, J., Petrich, M., & Wilkinson, K. (in press). Learning through STEM-rich tinkering: Findings from a jointly negotiated research project taken up in practice. *Science Education*.
- [2] Blikstein, P. (2013). Digital fabrication and ‘making’ in education: The democratization of invention. In J. Walter-Herrmann & C. Büching (Eds.), *FabLabs: Of Machines, Makers and Inventors*. Bielefeld, Germany: Transcript Publishers, pp. 1-21.
- [3] Brahms, L. J. (2014). Making as a learning process: Identifying and supporting family learning in informal settings (Doctoral dissertation, University of Pittsburgh).
- [4] Brahms, L. & Crowley, K. (under review). Families who make together: Locating and tracing learning in the context of informal family activity.
- [5] Cognizant (2011). Making the future: Today’s inspiration is tomorrow’s innovation. Retrieved on July 14th, 2015 from: <http://www.cognizant.com/about-cognizant/company-overview/sustainability/educational-opportunity>
- [6] Dorph, R. & Cannady (2014). Making the future: Promising evidence of influence. Lawrence Hall of Science & Cognizant. Retrieved on July 14th, 2014 from: <http://www.cognizant.com/SiteDocuments/Cognizant-making-the-future.pdf>
- [7] Engeström, Y. (1987). Learning by expanding: An activity-theoretical approach to developmental research. Helsinki: Orienta-Konsultit.
- [8] Engeström, Y. (2000). From individual action to collective activity and back: Developmental work research as an interventionist methodology. In P. Luff, J. Hindmarsh, & C. Heath (Eds.), *Workplace studies*. Cambridge: Cambridge University Press.
- [9] Engeström, Y., & Sannino, A. (2010) Studies of expansive learning: Foundations, findings and future challenges. *Educational Research Review*, doi:10.1016/j.edurev.2009.12.002
- [10] Gutwill, J. P., Hido, N. and Sindorf, L. (2015), Research to Practice: Observing Learning in Tinkering Activities. Curator: The Museum Journal, 58: 151–168. doi: 10.1111/cura.12105
- [11] Hasu, M. (2000). Blind men and the elephant: Implementation of a new artifact as an expansive possibility. *Outlines*, 2, 5–41.
- [12] Honey, M., & Kanter, D. (2013). *Design-Make-Play: Growing the next generation of science innovators*. New York: New York Hall of Science.
- [13] Ito, M., Gutierrez, K., Livingstone, S., Penuel, B., Rhodes, J., Salen, K., ... & Watkins, S. C. (2013). *Connected learning: An agenda for research and design*. Digital Media and Learning Research Hub.
- [14] Kärkkäinen, M. (1999). *Teams as breakers of traditional work practices: A longitudinal study of planning and implementing curriculum units in elementary school teacher teams*. Helsinki: University of Helsinki, Department of Education.
- [15] Makerspace.com. (2012). *The Makerspace Playbook*. Retrieved July 14th, 2015 from makerspace.com.
- [16] McKay, C., & Pepler, K. (2013). *MakerCart: A Mobile Fab Lab for the Classroom*. Position Paper at the Interaction Design for Children Conference (IDC), New York, NY.
- [17] National Science Foundation (2015). *Dear Colleague Letter: Enabling the Future of Making to Catalyze New Approaches in STEM Learning and Innovation*. Retrieved on July 14th, 2015 from: <http://www.nsf.gov/pubs/2015/nsf15086/nsf15086.jsp>
- [18] New York Hall of Science. (2013). A blueprint: Maker programs for youth. New York, NY: Author. Retrieved July 14th, 2015 from: http://dmp.nysci.org/system/files/filedepot/1/NYSCI_MAKE_R_BLUEPRINT.pdf
- [19] Pepler, K. (2013). STEAM-powered computing education: using E-textiles to integrate the arts and STEM. *Computer*, 46(9), 38-43. doi:10.1109/MC.2013.257
- [20] Petrich, M., Wilkinson, K., & Bevan, B. (2013). It looks like fun, but are they learning? In M. Honey & D. Kanter, (Eds.), *Design, make, play: Growing the next generation of STEM innovators* (pp. 50-70). New York: Routledge.
- [21] Quinn, H., & Bell, P. (2013). How designing, making, and playing relate to the learning goals of K-12 science education. In M. Honey & D. Kanter (Eds.), *Design, make, play: Growing the next generation of STEM innovators* (pp. 17-33). New York: Routledge.
- [22] Sfard, A. (1998). On two metaphors of learning and the dangers of choosing just one. *Educational Researcher*, 27(2), 4–13.
- [23] Sheridan, K., Halverson, E., Litts, B., Brahms, L., Jacobs-Priebe, L., & Owens, T. (In press). Learning in the making: A comparative case study of three makerspaces. *Harvard Educational Review*.
- [24] Stake, R. E. (2008). Qualitative case studies. In N. K. Denzin & Y. S. Lincoln (Eds.), *Strategies of qualitative inquiry* (3rd ed., pp. 119–150). Thousand Oaks, CA: Sage.
- [25] Vossoughi, S., Escudé, M., Kong, F., & Hooper, P. (2013). Tinkering, learning & equity in the after-school setting. Paper presented at FabLearn, Stanford, CA. Retrieved on August 24th, 2014 from: <http://fablearn.stanford.edu/2013/papers/>
- [26] Vossoughi, S., & Bevan, B. (2014). Making and Tinkering: A Review of the Literature. *National Research Council Committee on Out of School Time STEM*. Washington, DC: National Research Council, 1-55.
- [27] Wardrip, P. S., & Brahms, L. (2014). Mobile MAKESHOP: Preliminary Findings from Two School Sites. Poster presented at Fablearn Conference, Stanford, CA.
- [28] Wardrip, P.S. & Brahms, L. (in press). Making goes to school. In Pepler, K., Halverson, E. & Kafai, Y. (Eds.) (in press). *Makeology: Makers as Learners*. New York, NY: Routledge.
- [29] Young Makers (2012). *Maker Club Playbook*. Retrieved July 14, 2015 from: <http://makedred.org/youngmakers/>