

Makerspaces in the Making: Reconfiguring Cultures of Facilitation across the Kindergarten and the Science Museum.

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Introduction

During the last decade, makerspaces have become very popular across the world, and in Norway there are currently approximately 60 makerspaces across institutional and non-institutional settings. In these spaces, participants can design and create artefacts and solutions using a whole range of digital and material tools, thereby engaging in creative forms of enquiry-based learning that align well with current progressive education values and principles. In the education literature, the blending of the digital and the physical world, for instance through 3D printing or laser-cutting, and the engagement opportunities such blends bring about, are often emphasized (Blikstein, 2013). Unlike other enquiry-based forms of education, however, makerspaces are inspired by cultural movements that emerged outside of education and which involve, in addition to those enquiry-based qualities, values of democratic empowerment, autonomy and community-building (Halverson and Sheridan, 2014). In contrast to learning in formal education, makers have historically been characterized by having agency in deciding what they want to make, shifting their common role as consumers of ready-made products to become producers of their own products and learning. Local manufacturing, repairing and tinkering—which signal both autonomy and creative dimensions—have been an important part of the ethos of the maker movement.

When making is brought into formal institutional settings, what making is, and what it should be, becomes contested. As makerspaces have made their way into diverse educational institutional settings, such as schools, museums and libraries, research has only begun to emerge documenting the challenges and impacts of their implementation in these types of settings (Marsh et al., 2017). Particularly little is known about how maker practices can support young children’s creativity and engagement with science and technology topics (Britton, 2012) and how the agency- and community-oriented aspects of maker culture may translate into spaces where young children are the makers. Although we may accept a broad definition of making and argue that making has always been an important part of children’s everyday lives, and integral to the practices of early childhood education (Marsh et al., 2017, p.26), we still do not have a clear idea of what changes or reconfigurations makerspaces might bring about in young children’s already existing forms of engagement. Moreover, as the boundaries between formal and informal settings become increasingly blurred in modern societies, a question remains as to whether and how makerspaces can transform or reconfigure young children’s learning trajectories across diverse learning settings.

In this chapter, we are interested in the issue of agency as a central feature of makerspaces, and the challenges and opportunities that may emerge in that regard when such spaces are designed targeting young learners. Taking a cultural-historical theory perspective, according to which the “inner regulation of purposeful activity originates in external regulation” (Vygotsky and Luria, 1994, p.164), we conceive of children’s agency as a developmental manifestation of the ways in which social (including maker) activities are organized, and how these afford distinct forms of autonomous exploration, mastery and engagement. In this regard, research on making in museums and in schools has demonstrated that facilitation is a key issue when accounting for learners’ engagement (McCubbins, 2016). A central question in this chapter concerns, therefore, how different cultures of facilitation may afford different forms of agency and engagement in making.

We explore the question above in the context of a research-practice partnership between our university research team, a kindergarten and a science museum. Though seldom the focus of educational research literature on making, such inter-institutional partnerships bring with them tensions and transformational opportunities that are important to consider when designing innovative spaces for learning (Jornet and Jahreie, 2013). Our research on cultures of facilitation and agency thus connects with the issue of learning across contexts, and it brings with it a concern for the ways in which efforts to implement makerspaces come to reconfigure already existing social and cultural facilitation practices. More specifically, we explore how the work of designing and implementing makerspaces elicits new design concepts as well as ways of constructing time-space configurations or *chronotopes* (Bakhtin, 1982; Ritella, Ligorio and Hakkarainen, 2016).

To address these questions, we take and discuss a *design-based research* approach (Barab and Squire, 2004; Penuel, Cole and O’Neill, 2016). From this perspective, the making of makerspaces becomes itself a site of and for enquiry, where we explore how the task of designing and implementing innovative learning environments becomes an opportunity to disrupt, restructure and reconfigure already established norms, routines, values and time-space configurations. Our specific contribution thus relates to how makerspaces, through design-based participatory research, can be designed for creative making across learning settings, analysing those designs and exploring how making for young children can be facilitated and supported.

Makerspaces as Disruptive Spaces

Recently, the education potential of makerspaces has been emphasised and making has become a recurrent way of creating interest in STEM subjects for children and young people

in both formal and informal learning settings (Bevan et al., 2016). Educational research tends to emphasize how makerspaces offer engaging and interesting activities that children find motivating. For instance, makerspaces have been shown to support experiential and constructionist pedagogies, where children can develop their abilities to design and produce things (Shrock, 2014). As a practice and global phenomenon, however, making and makerspaces first emerged outside of institutions, precisely as a way to contest the consumerist established ethos of modern culture and its tendency to undermine autonomy and creativity. It emphasizes agency and auto-determination; it involves community building but also, and at the same time, the subverting of mainstream culture (Dougherty, 2016). Connections between these socio-historical roots and the relevance of making in/for education are often highlighted to emphasize the creative and motivational potential of makerspaces as places for learning and education. But the extent to which it can be assumed that making in educational (formal and informal) settings brings with it some of the qualities that characterized that original social movement is of course an empirical question. There is a risk that the entrepreneurial spirit, creativity and culture of sharing that characterise makerspaces will be “domesticated” when they become part of institutional school-like practices (Dougherty, 2012). Making may be particularly difficult to reconcile with the types of activities tightly structured by curricular goals, procedures and institutional rules that characterize formal schooling, where issues of assessment often come to the fore.

There exists the possibility, however, that rather than simply becoming “domesticated” when educators attempt to implement making, designing makerspaces may work as a *boundary practice* (Wenger, 2000), i.e. as something that might expand, challenge and disrupt established educational practices. Prior research has shown how inter-disciplinary, multi-professional collaborations that aim to design novel spaces for learning themselves become contested places in which the very notion of learning and the practices that aim to support it become transformed in and through design work (Jornet and Jahreie, 2013; Jornet and Steier, 2015; Smørdal, Stuedahl and Sem, 2014). In this regard, the idea that makerspaces may act as *disruptive* places that shake up established forms of teaching and learning practice has been advanced in the literature (Bliksten, 2013, p.6). This idea stems from the notion of *innovative disruption*, initially formulated in market research (but which has more recently been applied to education as a means to theorize ways in which technological and pedagogical innovations work as disruptive devices that—often unintentionally and in unforeseen ways—destabilize established norms and values). As a result, “what were valuable improvements before the disruption now are less relevant. And dimensions ... that had been unimportant become highly valued” (Christensen, Horn and Johnson, 2011, p.44).

In studies investigating makerspaces, the idea of disruption has been explored with regard to the social materiality of given technologies such as electronic textiles (Kafai, Fields and Searle, 2014). In this regard, Kafai and colleagues documented how “bringing maker activities like e-textiles into schools disrupts the notion of ‘right’” (p.535) as well as gendered

expectations with regard to engagement with technology. Though not directly using the notion, other ethnographic studies sensitive to makerspaces' cultural-historical dimensions have concluded that, in makerspaces, "who can make and who cannot, whose knowledge matters and whose does not, are all a part of making itself" (Barton, Tan and Greenberg, 2017, p.2). Such studies make visible some of the cultural tensions and transformational potential that come into play when makerspaces are implemented as part of educationally-oriented projects.

Yet, a significant amount of the design and research literature on making is inspired by constructionist ideas (Papert, 1993), where the focus is on learning and creativity affordances, and where cultural tensions are rarely addressed. With regard to agency and creativity, researchers have been concerned with the development of models that enable us to identify the learning happening in makerspaces. For example, Bevan et al. (2006) identified engagement, initiative and intentionality, social scaffolding and the development of understanding as crucial elements of such a model. Research also demonstrates how previous interests can occasion engagement in making, and explicit orientations to STEM topics by adults can result in more positive attitudes towards STEM (Davis and Mason, 2016). Sheridan et al. (2014) also found that makerspaces could be beneficial for STEM-education, because they allow participants to actively seek knowledge they need to complete their tasks. In all cases, how adults (facilitators, educators) and institutional tasks frame activities is highlighted as a relevant, though often unexplored, feature (Barton et al., 2017) These studies, therefore, are relevant to our quest to understand how agency and creativity may develop as a function of facilitation practices in makerspaces. However, a problem with constructionist accounts is the lack of orientation to how engagement, learning and facilitation dynamically interact with one another (Arnseth and Krangle, 2016).

There is, therefore, a need for studies to document and account for the tensions and potential for cultural transformation that lie at the intersection of established and yet-to-be established practices, and how these tensions play out at different levels, including the personal, the social and the institutional. This need is particularly acute in the case of young learners, where achieving the pedagogical values of autonomy and creative agency recognized in maker cultures may require reconsidering the implicit and explicit assumptions embedded in existing social and cultural forms of facilitation. Moreover, there is a need to adopt methodologies that are suitable to understand not just the educational opportunities that emerge in makerspaces but also the opportunities that emerge for social and institutional change in the making of such spaces. In this study, we explore and exhibit the use of design-based approach methods as a suitable method, where the development of design concepts that emerge as a means to deal with the emerging tensions becomes the analytical focus. Accordingly, our research questions are as follows:

- How does the design and implementation of makerspaces disrupt and reconfigure cultures of facilitation in a multi-disciplinary group of educators at the intersection of the kindergarten and the science museum?

- What design concepts and tools emerge through such reconfiguration?

Spaces in the Making: A Design-based Research Approach and its Cultural-historical Framework

Cultural-historical framework

In this chapter, we pursue a cultural-historical approach to designing and analysing making for young children. A cultural-historical approach shares with social cognitive theory the view that ‘people are producers as well as products of social systems’ (Bandura, 2001, p. 1). Human agency is a function of ways of organizing activities. It distinguishes itself from other frameworks, however, in that it posits a *genetic* relation that unites often-thought-of-as individual psychological features with collective historical, societal objects. This genetic relation becomes the focus of analysis, thereby defining personal motivation as being an emergent function of the collective and historical *motives* that organise cultural contexts of practice (such as the school, the home) (Leontiev, 1977/2009). It is by participating in concrete, action-oriented collective activities that learners develop understanding along with agency and identity, all of which are central to engagement (Lave and Wenger, 1991). From this perspective, learning phenomena are not either individual or social, but rather *cultural historical objects* that develop in and through human practices. It is therefore possible to address makerspaces as historical objects, and to attempt to understand how these objects develop and transform in and through becoming appropriated by other already existing practices, such as the practice of running educational programmes in science museums or of educating children in kindergartens (the two settings examined in this study).

In relation to making, language and action are interrelated and both contribute to the emergent character of making as a process and product. In contrast, the main idea in constructionist pedagogies is to see these processes as distinct. The process in fact starts with developing and articulating an idea either individually or together with others and then creating an external representation or model of that idea (Kafai, 2006; Kafai and Resnick, 1996). It is in the concrete and material work of pursuing that idea that not only the idea, but also new embodied and conceptual orientations, emerges in the participants, such that the very understanding of the object of the joint activity changes (Jornet and Jahreie, 2013; Jornet and Steier, 2015). In this regard, a cultural-historical framework focuses on the development of practical and discursive cultural resources as a means to deal with emerging tensions and understandings. In the context of design, this involves focusing on the *design concepts* that emerge as members from different backgrounds and with different interests work out ways of achieving a common project and object of activity.

In line with the overall MakeY project approach exhibited throughout this book, one of the main implications of a cultural-historical approach to making and the making of makerspaces is that learning phenomena are investigated as existing across multiple historical levels of analysis. Thus, the changes and conceptual development discussed above do not only involve those learners participating in the designed makerspaces, but also the designers and the very physical and institutional settings as part of which makerspaces are appropriated as a form of pedagogy. As a cultural and historical phenomenon, makerspaces, as they are appropriated in contemporary educational agendas of different institutional contexts, are phenomena that develop at personal, inter-personal and institutional levels. At the personal level, we are concerned with investigating how issues of agency, interest and engagement play out in social interaction. Children's previous participation in practices inside and outside of school, which in many ways is sedimented in their subjectivities, is also made relevant, oriented to and has an impact on present activity (Holland et al., 1998). An interest in the personal level also means that we are interested in the values and beliefs that educators bring to the setting, as actual courses of action, and how they bring about new and projected identities for possible future participation in making. We also focus on the personal meanings children make in these spaces and whether their motivations are facilitated through interacting with educators and through using the tools made available to them in the space.

At the inter-personal level, the focus concerns how issues of creativity and agency are constituted socially and relationally in and through the planning and implementation of a makerspace. This level is often referred to as socio-genesis in sociocultural theorising. This is where people and tools come together in practices, and it is here that they get their actual sense and function for the participants involved. With regard to tools, a main focus in our study is how participants deal with and formulate design concepts as they tackle emerging tensions and contradictions. Heterogeneity is an integral feature of any social practice. This is also the case for makerspaces, which is a space where multiple ideologies, ideas and interests become visible. The actual outcomes of practices in makerspaces are the result of complex negotiations between the identities and interests of children, of educators and other stakeholders.

The institutional level involves an interest in how institutional practices, where particular historically developed institutional roles and objectives are made relevant, impact on children's creative making in the museum. Our particular interest here relates to how the makerspace is situated in a museum and part of the museum's educational programme. Institutional histories, norms and interests have an impact on how the makerspace is realised in this particular institution. However, the institution is not a stable context for activity; institutions can also be transformed through practices. What is interesting with a design-based methodology is to investigate precisely how and if institutional practices can be changed and transformed and what impacts on change and transformation. In this study, we follow how the

work of making a makerspace leads to the development and transformation of ways of conceptualizing and going about facilitation practice.

Design-based approach: Considering the making of makerspaces

The cultural-historical perspective taken has methodological implications that are grounded in the view that one way to understand a social practice is by *changing* it. That is, to understand how agency and creativity emerge as part of the implementation of makerspaces, we need to understand *the making of* makerspaces as purposeful intervention sites, themselves contested sites of creativity and imagination that involve change and disruption of existing forms of institutional organization and social participation. In this regard, a method that considers both the learning spaces designed and their designing as part of a unitary methodological process is design-based research (Barab and Squire, 2004). When approached from a cultural-historical perspective, design-based research methodologies approach learning research objects or phenomena not as merely existing out there to be researched, but also and at the same time as outcomes of purposeful design activity. The objects of learning research, then, are artificial; they are the outcome of human practices, and they are so in a double sense. According to Cole and Packer (2016), “design research must grapple with the *doubly artificial*, as the classrooms in which many educational designs are implemented are themselves already artificial and contingent—the products of design—and the learning that is the focus of investigation is already an adaptation to the classroom environment and so artificial” (p. 503).

A design-based perspective builds upon principles of participatory design in which partnerships are established between researchers, educators and other relevant stakeholders. In design-based research, theory-driven innovative educational environments are designed while experimental studies are simultaneously carried out to assess those innovations. Aspects of the environment are systematically manipulated, in order to observe and understand which practice works best (Barab and Squire, 2004). Typically, this involves iterative cycles of implementing, assessing and refining practice. Outcomes are thus of both theoretical and practical value. With regard to makerspace design and research, designing creative spaces while engaging in active conversation with other stakeholders can allow us to create relational patterns that support new conversations among children and educators. At the same time, designing and implementing makerspaces opens up opportunities for intra- and inter-institutional tensions that become visible when a new historical object emerges that requires different views and takes. Opportunities then open up for developing new design concepts that orient participants towards new forms of praxis.

Data Collection Methods and Participants

This chapter reports on a case study deriving from a participatory research initiative involving a university, a science museum and a kindergarten in Norway, which collaborated to develop and explore design concepts for makerspaces targeting 5–6-year-old children. The research comprised an iterative and cyclical design involving several data collection points, including initial ethnographic observations of children playing in their kindergarten and during existing activities at the museum. These observations and knowledge from prior experiences in both settings became input to exploratory design meetings where the goal was to design a making activity. Using a cultural-historical approach, we identified design *bridging concepts* and analysed the ways in which the socio-material conditions surrounding the design and implementation of the resulting activity supported and/or hindered opportunities for agency and creativity.

To analyse and develop cultures of creative making in and across the science museum and the kindergarten, from our design-based perspective we were mindful to follow a participatory design approach (Bang and Vossoughi, 2016). This would ensure that the research problems were grounded in the participants' interests and concerns. Although our efforts were inspired by design-based research, unlike typical studies within this tradition, we did not explicitly aim to test and redevelop specific design principles. Rather, the iterations were the result of negotiations of these interests and constituted an attempt to put them into practice. We focus on the challenges and opportunities when collaborating with practitioners, and how museums can facilitate creative making activities for young children. We also provide descriptions on a more institutional level concerning how making can be constituted very differently within the two settings, but also how connections between the settings can be made in regard to children's experiences with making activities. We analyse more in detail the different ways that practitioners support children's making and how the characteristics of their support influence the development of children's creative processes and practices.

Participants included (a) a team of researchers, including five educational researchers with different experience and focus but sharing a concern with the design and understanding of technology-enhanced spaces for learning; (b) a team of three museum curators and educators who have a specific responsibility for developing science enquiry experiences for young children in the science museum; (c) and four kindergarten educators from a kindergarten in the Oslo area, along with a group of twenty kindergarten children between 5 and 6 years old. The kindergarten was located close to the museum, which is situated in a typical middle-class area. We recruited the kindergarten through the museum. They had already signed up for an activity and we contacted them and asked if they would let us observe them when they visited the museum. All but one of the children assented to participating in the project.

Since September 2017, the participatory design process has involved design meetings, as well as observations in the science museum and the kindergarten. In addition, we have conducted

interviews with museum and kindergarten educators during the process. All of the above were recorded using traditional zoom-lens cameras, as well as wide-angle action cameras, to ensure adequately capturing embodied interaction in both the design and the designed spaces. Data collection milestones during this process are detailed in Figure 1. We started by observing an existing activity in the museum. Then, we arranged a design meeting with museum staff where the goal was to design a making activity. After that, we observed children involved in arts-based activities in the kindergarten, in order to document the participants' native "maker-like" competences. Finally, we observed children engaging in a new making activity in the museum. As part of our participatory research, we held three exploratory design meetings with partners in the project.

Building on the insights gained and observations made, we developed an activity where we aimed to foster children's creative making in relation to the issue of sustainable development. Based on a series of workshops in which we collected data and created concepts for designs, we ran an intervention in March 2018. Taken together the data collection comprised five workshops.

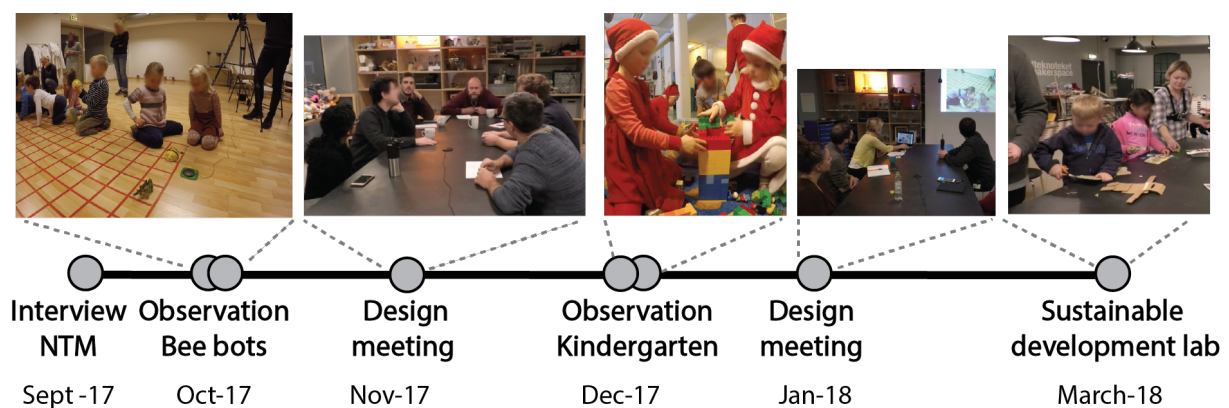


Figure 1: Data collection milestones along iterative design process.

Case study: making a makerspace for kindergarten children in the science museum

In the sections below, we summarize the results of our ethnographic observations and interviews documenting the process of designing and implementing a makerspace at a science museum targeting kindergarten visits. We show how, through a process of confronting the task of developing a makerspace activity for young children, established but otherwise tacit assumptions about and the practice of facilitating children's agency and creativity become visible, workable and contested. Tensions and disruptions become visible in actual interactions between adults, as they discuss and formulate challenges and possible solutions, but also between adults and children during the implementation of actual facilitation practices.

When, through the iterative design process, adults reflect back on their experiences, a transition from the personal to the interpersonal (relational) takes place. A change in the design concepts then becomes a means to deal with the emerging tensions on the interpersonal plane, orienting participants towards new horizons of (pedagogical) activity.

We present the development trajectory described above in terms of a summary narrative that intertwines three levels of analysis (personal, social, institutional). The narrative approaches the emergent object of design, i.e. the yet-to-be makerspace, as a transforming object that changes and is changed by the social relations involved in its making (hence the title *Makerspaces in the Making*). More specifically, as the work of designing a makerspace for young children in the science museum unfolds, tensions and contradictions emerge with regard to a practical and sensuous aspect of facilitating agency and creativity in making for young children. These tensions manifest in the participants' struggles to find a balance between providing the children with enough *structure* while at the same time providing them with an open frame allowing them to gain agency and develop a creative stance.

A need/motive emerges

As a historical and global object, makerspaces have grown in popularity in recent years. In Norway, too, makerspaces have become more popular and are being increasingly planned and implemented as part of diverse public cultural spaces, such as libraries and museums. The Museum of Science and Technology (NTM in Norwegian abbreviation) in particular has been a leading actor in this regard, having organized and hosted the first Maker Fair in Norway, as well as having established a dedicated makerspace in the museum. At the weekend, the space is open to visitors of all ages, but on weekdays and during special events, the makerspace is most often offered and reserved for older children and adults. At the moment our research began, there were no activities offered for children of kindergarten age.

An interest in makerspaces has simultaneously grown in educational research, as reviewed in previous sections. As an academic area of interest, this focus does not only manifest in the increasing number of research articles published about the topic, but also in the stimulation of research-practice partnerships where makerspaces acquire new meaning not only as sites for learners' experimentation but also for experiments concerning the pedagogical (teaching-learning) potentials embedded in such spaces. The MakeEY project is but another manifestation of this interest as it concerns extending research into the early years. And it is as part of this experimental concern and orientation that we, a group of educational researchers from the University of Oslo, approached NTM to learn about and discuss their approach.

Facilitation emerges as a challenge/focal concern

A challenge concerning facilitation emerged as a central challenge and focal concern of the research-practice partnership very early in the trajectory. Thus, during an initial meeting/interview with Carl (pseudonym)—one of the museum curators in charge of the museum’s educational programmes—as the researchers (Jan and Audun) were articulating “their” interest in exploring maker-like activities, the issue of facilitation emerged as a key factor in achieving a common understanding of the emerging task.

Fragment 1

- 01 Carl: but were you thinking that you would like to test out a set-up that is already offered or more like a free...
02 Jan: perhaps a bit free, yes,
03 Carl: but which is not organised?
04 Jan: no. It needs to be facilitated in one or other way, be supported.
05 Carl: uhum.

In Fragment 1, we observe how a turn (01) seeking to clarify whether what had been said before about the researchers’ goals involved testing something “like a free...”. We do not hear the speaker fully articulate the statement, but Jan, one of the researchers confirms that this is “a bit free”, possibly as opposed to a set-up that is already organised as part of the museum’s offer. Yet, Carl requests further clarification, “but which is not organised?” to which Jan responds in the negative, arguing that “it needs to be facilitated” (turn 03).

In this exchange, facilitation is jointly articulated as a key feature that requires repair and clarification work during the initial work of establishing a common project. Throughout that and further conversations, there is a need to address to what extent and in which ways the target maker activity should be facilitated, particularly given the group’s age. Soon after, during the same conversation, the curator clarifies that they “do not currently offer something in the makerspace, as long as I know, for that age group” (Interview 1, September 2017). The conversation moves on to discuss which age group is the lowest for which activities in the makerspace are offered (grades 4–5), and the type of activities that are indeed offered to younger children. The question of facilitation is thereby taken up again, but becomes further elaborated as one involving a challenge to find an adequate balance between providing young visitors with enough structure, while at the same time giving them enough freedom and agency to pursue their own goals and creativity. Carl mentions a particular activity (Strawbees¹) that had recently been re-designed precisely to address this challenge:

“the reason that it was re-made was that you had a completely free set-up that did not work so well, because children became frustrated. They did not know what they should

¹ Trade Mark: <https://strawbees.com/about-us/>

do ... such that they faded out or just sat there cutting straw without any goal...”
(Interview 1, September 27)

The concern Carl articulates characterizes not only issues the museum deals with, but is also shared among most studies on learner-centred, progressive pedagogies. When Carl articulates it as part of a conversational repair, this is immediately taken up by the researchers, who clearly are sensitive to and familiar with the issue. The tension between structure and freedom, guidance and self-direction, is also a concern present in creativity research, where the question of whether and to what extent structure and constraints enable or hinder creativity has long been posed (Sawyer, 2012).

In the context of our research, this concern—with historical roots outside our research project and the specific settings involved—increasingly becomes a need and a motive in the sense that, for the shared object to evolve, the issue of facilitation needs to be addressed. The very idea of having a makerspace activity for young children begins to be built around a definition of whether and to what extent a maker activity is supported, and how. As we shall see, it is through developing discourse and tools in order to deal with this concern that the work of designing a makerspace becomes disruptive and leads to the possibility of (personal, social, institutional) change.

Making in the kindergarten and in the science museum: Different chronotopes and cultures of facilitation

As part of our participatory design-based approach, we enlisted as active partners a kindergarten that had already signed up to join one of the educational activities in the museum offered to kindergartens. As described in the methods section, following a group of children and educators from this kindergarten allowed us to document already existing practices in both the science museum and the kindergarten. Such observations allowed us to characterize the different settings involved.

One way to characterize the agency and creativity facilitation practices in the museum and in the kindergarten is by describing how these are organized differently in terms of time and space orientations or *chronotopes* (Arnseth, Silseth and Hanghøj, 2019; Ritella et al., 2016). In this regard, the organization of time and space in the kindergarten may be best described as being somewhat circular in that activities tend not to be limited by time—any creative activity can go on for a long time and may always be continued the day after—and by space—where kindergarten spaces are places to be in for children, not just to visit or pass through. It is the daily routines that provide rhythm and structure to practices, and not an orientation towards

given outcomes. It is a place where they are gradually gaining agency and developing ways of being in the world throughout a broad spectrum of skills, including everyday conduct skills, but also intellectual, literacy and artistic competences.

Most relevant to our focus on making, when children engage in creative making in the kindergarten, there appears to be no rush to create a final product, nor is there any prominent orientation towards that product. The social organization of activities and the facilitation that goes into them is not oriented towards making *something*, but towards the *making* itself. In this sense, the kindergarten exhibits what in the design and creativity literature has been referred to as an *intransitive* approach to making (Jornet and Roth, 2018). The latter approach emphasizes the fluid, processual nature that verbs such as to make, to draw or to read mark when they do not have a grammatical object. Thus, when a verb like “to make” takes a transitive form, it always brings an object with it: “I make *this thing*” or “I read *this book*.” In the intransitive form, there is no object and all the emphasis goes into the verb. “I *make*” or “I *read*” then become ends in and of themselves as form-giving processes.

We observed the latter orientation in every creative activity in the kindergarten, including an artistic painting activity that had been offered as an option along with three other possibilities (playing with play dough, playing with Lego bricks, composing stories on a digital tablet). Only those children who chose painting joined the drawing table, suggesting a quite open form of agency in which children are led into an environment in which they are supported to feel safe and confident and are invited to make choices with respect to the types of activities that they want to engage in. Once they had gathered, they were given a blank canvas and the instruction: “we will now paint something having to do with Christmas” (Kindergarten educator, December 2017). Fragment 2 illustrates the ensuing conversation.

Fragment 2

- Child 1: reindeer?
Teacher: if you want to paint a reindeer you can paint a reindeer,
Child 2: or nissen²?
Teacher: or nissen.
Child 3: or Santa’s hat,
Teacher: or Santa’s hat,
Child 1: or a Christmas tree,
Teacher: or a Christmas tree
Child 1: I will paint a Christmas tree
...

² Wikipedia defines a “Nissen” as a “mythological creature from [Nordic folklore](#) today typically associated with the [winter solstice](#) and the [Christmas season](#)”.

Teacher: but we will paint something having to do with Christmas, so perhaps you will choose yourself what to paint.

Fragment 2 displays a form of facilitation in which an overall goal is given, namely painting something “having to do with Christmas”, as it is that time of the year. They are given a clear, yet broad enough frame as part of which the children are able to suggest a diversity of motives. For each suggestion, the teacher simply repeats the child’s suggestion and then restates the general frame, i.e., that it must be something to do with Christmas. Interestingly enough, although the children come up with a diversity of suggestions, as the paintings begin to take form, we can see that all but one child ends up painting the same motif (a Christmas tree). Yet, the fact does not become an issue during the session, and a new canvas is provided after each child is done, so that further works can be produced.



Figure 2: Children painting in the kindergarten. At the left, children begin with a blank canvas; the image on the right shows the same activity a little later, most children having painted a Christmas tree.

The interaction above nicely illustrates how practices of making and facilitation present in the kindergarten focus on the doing of things as opportunities for gradually building agency in and through making, such that this and other aspects of social competence grow while making. This orientation to making in the intransitive form is also illustrated in Figure 3, where two children spend a substantial part of the morning building a tower together, one that grows indefinitely, without limit, until the children somehow randomly decide it is tall enough. Rather than working with an “end in mind”, it seemed that simply working, letting the emergent sensuous activity lead without an end in mind, was at stake.



Figure 3: two kindergarten girls building a tower with blocks.

By contrast, the types of activities in which young children engage in the museum as part of visiting groups are very different. The motive or object in the centre as an activity system is to provide young people with engaging and fun experiences of science, offering a variety of materials and installations, the value of which is that they are not accessible in other educational and/or everyday settings. Again, describing the type of chronotype involved helps. The organization of time and space in the museum, because of constraints inherent to the nature of the activities, is very structured. Museums need to accommodate for given numbers and diversity of visitors, and they need to schedule activities and projects accordingly. Groups of students visit for short periods of time and follow tightly scheduled activities, which are supported by the museum educators.

One example of such scheduled activity for young children is a Bee Bot³ based activity in which children learn to program a bot such that it moves through space to reach a target, often a toy flower. This activity can be done on any surface, and the bot constraints consist of a set of fixed front, back, right or left movements that can be programmed in advance by pressing the bot's control buttons. In many ways this is a toy-based version of Semour Paperts "Logo Turtle". The aim is for children to learn computational thinking. In the museum activity targeting children, the task has been further structured by inscribing a grid on the floor (Fig. 5). Each square in the grid has been marked out as the length of each move that the Bee Bot makes. This makes it easier for the children to keep track of how many steps. In addition, adults (kindergarten teachers and museum educators) are present to further facilitate the children's task.

³ Bee Bot is a trade mark: <https://www.bee-bot.us>



Figure 4: Bee Bot activity at the science museum. The floor has been enhanced with a grid to structure the children's activity of counting.

As the description above suggests, the form of facilitation here is tightly organized to ensure that an end goal is reached, here getting the Bee Bot to reach the flower and avoid obstacles in its way. The task requires an intensive structure for various reasons connected to the young age of the participants, including the fact that some of the literacies required are still being learned, but also the fact that the frames for participation and goals are very unlike those in the kindergarten, and they need to be built quickly within the short-time frame of the visit. One of the kindergarten educators noted this gap in an interview following the activity:

[in situations like bee-bots,] you can see that there is great diversity ... some get it very quickly and some don't really understand. A bit more of time would help ... It is when the kids have got some time to master something that they begin to be creative. (Kindergarten Educator, Interview October 2017)

Although clearly hands-on and engaging, the creative and agency-related qualities of making are here absent. The goal was not creative making but to learn to solve a very procedural task. Thus, the structural set-up of the activity and the task did not require any creativity on the part of the children. They only needed to infer the relation between the grid and the buttons they needed to push on the bee-bot. In a sense this was a very instructional task, one characteristic

of school practices but with which the children from the kindergarten were not necessarily very familiar. As we collaborated with the museum, the joint goal of designing a maker activity was still one where the structuring frames would allow the children to participate meaningfully while also supporting creative and agency engagement.

Jointly defining a makerspace (between the kindergarten and the museum)

Once we established the initial shared goal of exploring possible set-ups for maker-like activities at the museum targeting young children, we arranged a series of design meetings as part of our participatory design-based approach. In a first meeting (November 2017), initial ideas around and difficulties with defining what a makerspace is and what it may look like when it comes to engaging young children was at the centre. It is in that sense interesting to explore how makerspaces, as historical objects, make their way into other settings and historical purposes through joint collaboration.

One of the things that characterize the maker movement as part of which makerspaces emerged as promising arenas for formal and informal education consists is the fact that ordinary people, indeed anyone, may become an agent and builder of her own products, hence leading to less consumerist and more democratic forms of production and consumption. The fact that something is produced is important. In the context of our design-based research, this historical aspect of makerspaces as a societal form of organization manifested as the participants began formulating what a makerspace may mean as a space for learning in science museums.

The interdisciplinary group (3 educational researchers, 2 museum curators/ educators and a museum technician) was in the midst of discussing to what extent technological and digital components were desired or required as a feature, with arguments being raised that low-tech solutions might be more solid and retain just as much pedagogical value. At that point, the question was raised, “What would be the required criteria for this to be a makerspace activity?” (researcher, WP1). The curators then began formulating what a space or activity should include to be a makerspace. Summarizing here, the group jointly articulated that, “Something must be created,” “which they [the visitors] can take home,” and “must be open-ended to some extent.” Moreover, the object produced must be “something you think gives you something positive” that “has a value.” The idea that the activity needs to include some electronic or digital element, on the other hand, was discarded as a criterion. And as the group kept discussing these ideas, it became more difficult to discern how what goes on in kindergartens could not also be considered a form of making. This was before we had conducted observations at the kindergarten, and it was then agreed that we needed to get to better understand creativity and agency practices at the kindergarten.



Figure 5: Educational researchers and museum educators during Workshop II, where images and observations from the kindergarten were displayed and discussed.

Observations from the kindergarten were shared and discussed during the second design meeting.⁴ Among other cases, the painting example discussed above was taken up in the meeting. A positioning emerged in which the fact that the children had ended up painting the same image despite having been given the space and agency to choose—an issue that was never marked as problematic at the kindergarten—came to be seen from a deficit perspective: there had not been more creativity because the frame the kindergarten educator had given was too broad. A possibility for more clearly differentiating between the type of “making” that goes on in kindergartens and the type of making that the museum could offer began to be articulated around the idea of further stimulating creativity in the sense of a diversity of unique products (i.e. as opposed to almost everyone painting the same thing).

Constraints for creativity as a design concept

As discussed above, during the second design meeting, the need to address the tension between structure and freedom that had already emerged as a focal concern in the first interview began to be intertwined with the task of defining what a makerspace activity for children in the museum might look like. If earlier on during the design trajectory there had been doubts about the extent to which kindergartens were themselves makerspaces, now the role and place of the envisioned makerspace activity for children in the science museum

⁴ Three educational researchers and two museum educators participated in that meeting. A teacher from the kindergarten who had been invited and had agreed to participate could not come in the end.

began to be formulated precisely by articulating how the planned activity could offer an alternative way of facilitating the creative process.

Against this background, the museum educators recalled and presented during the meeting an activity called (in Norwegian) “Kreativt Klimaverksted” (Sustainable Development Lab). The idea was based on the fact that makerspaces generate lots of rubbish, and this rubbish could be re-used as material for other making activities. In those activities, recycled materials could be used as a means to address environmental issues (hence thematic sustainability). The activity was particularly interesting and pertinent for the ongoing conversation for, unlike a blank canvas that may end up serving to paint the same Christmas tree, using bits and pieces from a trash bin made it virtually impossible for two children to create the same thing, for each bit and piece is uniquely different. Furthermore, and also in line with what the discussions had been revolving around, the activity had been designed to stimulate creativity by forcing participants to choose two words (a noun and a verb) laser-printed over small wooden planks. Children would then use those combinations of verbs/ nouns randomly put together (e.g. work, store), as “constraints” (curator, design meeting II).

The notion of *constraints for creativity* was quickly taken up and functioned as a bridging concept to address the tensions between the need to offer open and exploratory opportunities while scaffolding young children’s participation in making. Considering the age group that was the target, participants quickly agreed that there would be a need to adjust the activity for kindergarten visitors. One idea was to use pictures instead of words, in case some of the participants could not yet read, as a means “to scale down” the activity for the target age. The materials for the activity were generated during the following weeks, including pictures as stimuli⁵ for ideas and creativity (Fig. 7). One stack of cards contained pictures related to pollution and the environment, while another contained pictures of things like tractors, bulldozers, policemen or nurses. The children could combine pictures from each stack and use them as inspiration to come up with new, creative solutions. As a task, the children would be given the mission to create an invention that would address the issue of sustainable development.

⁵ Readers familiar with cultural-historical theory may recognize an inspiration in Vygotsky’s theory of double stimulation (Vygotsky, 1978). In the classical formulation, a second stimulus is introduced into an activity and this can function as a mediation device for the relation between the first stimulus and the object of the activity. Providing apparently unrelated stimuli is also a stimulating technique well known in the literature on creativity (Sawyer, 2012).



Figure 7: Examples of pictures that were used as stimuli to “constrain” the production of ideas during the maker activity.

Refining the concepts, reconfiguring the spaces

The scaled down “Sustainable Development Lab” was tested out with the same kindergarten students that had been followed throughout the design trajectory. The task was run twice as the children were divided into two main groups. Students were first introduced to the problem or challenge—inventing something to collect plastic from the sea—in plenum, and then, in smaller groups, they were given the chance to choose images as stimuli for ideas. Then they would get a box with trash, scissors and glue and, helped by an adult in each group, they went into making things—boats, machines etc.—that would help to clean up plastic from the sea.

After the hands-on activities, museum staff, researchers and kindergarten educators got the chance to reflect back and further develop the emerging concepts and ideas. Overall, the experience had been positive for everyone, including the children who built artefacts and had fun. But there were some difficulties too. A consensus among the museum educators and kindergarten educators was that the pictures as “constraints for creativity” had not worked as planned: “...the pictures, I don’t think they understood what they were ... how should one put them together” ... ”they were concerned with getting a picture ... not about listening to what was coming ... as soon as [they get the pictures] they disconnect from what is being said” (Kindergarten Educator). There were complaints that these were too abstract. The museum staff specifically were concerned that, in addition, there was a constant need to facilitate the activity; the children needed guidance or else were off-task, a situation that may be unrealistic with respect to the museum’s resources during normal operation.

Throughout the evaluation, new opportunities emerged to re-conceptualise the goals and ideas that had been developed so far, including the concept of “constraints for creativity”. These opportunities came up along with personal experiences confronting the very historical objects

that had been the object of the design work all along: the challenges of facilitation and of finding a balance between structure and freedom. One museum curator expressed having felt that the situation was “very difficult” and that on several occasion he sensed how “the children just wanted to experiment with how they could use this straw and things like that” but he also felt this might destroy the activity flow. He wondered “whether it was the children’s creativity or the adults’ leading that becomes visible through the children’s work” (museum curator). A more decided reflection came from the kindergarten teacher, who argued:

“It is the creative process that is important, it is not the product that is important ... so it is us, the adults, who have the biggest problem. Because we want it to become something ... The process, it is then when they have fun. They forgot before they came out of there that there was something they had made.” (kindergarten teacher)

Apparent in the reflections is a sense that formulating the concept of “constraints for creativity” in terms of pictures as stimuli was too narrow a formulation, and that further work was need to elaborate on the concept, as that work could further transform the personal and institutional experiences and relations of the members involved, including those of the children.

Discussion and concluding remarks

In this chapter, we have exhibited a design-based perspective as a means to address the disruptive and transformational character of makerspaces targeting agency and creativity in young children as this develops across different levels of analysis (personal, interpersonal and institutional levels). We have shown how tensions and opportunities for change that are brought about by the actual design and implementation of makerspaces across diverse institutional settings can be understood as historical tensions that unfold across multiple levels. By making these tensions and the emerging concepts that participants generate to deal with them the focus of our analyses, our findings contribute to the literature on makerspaces as generative places for pedagogical innovation, and not as ready-made teaching solutions that can unproblematically be appropriated in formal educational contexts.

We have argued that to explore how makerspaces can offer new learning experiences for children and the mechanisms that facilitate the development of children’s digital literacies and creativity, it is not enough to look at how different designs lead to different learning experiences. Whereas much of the existing literature on makerspaces in/for learning has focused on constructivist/ constructionist premises and has been limited to looking at the learning happening or failing to happen in designed environments, research also suggests the

need to approach makerspaces as sites of cultural disruption by means of which established values and meaning-making practices can be challenged and potentially transformed (Barton et al., 2016; Blikstein, 2013). Therefore, it is also critical to examine and explore pedagogies and forms of social organization that can enable us to develop children's digital literacies, and how these pedagogies build upon institutionally supported frameworks. Understanding how agency and creativity may develop as a function of facilitation practices in makerspaces, therefore, requires not only looking at already established activities, but also at the process of *making* those activities actually happen.

In our study we have taken a cultural-historical approach to account for the way makerspaces are making their way into education, and how these intertwining contexts for learning are re-configuring each other in and through personal and interpersonal experiences, which are, in turn, mediated or facilitated by given institutional practices. But our study also shows how these very institutional practices, in turn, also change. A crucial way in which historical tensions and contradictions become transformative forces as they, as historical practices, are appropriated in new contexts is through the concrete labour in which members engage to make sense and develop concepts and tools to address the newly emerging conditions that this very work creates. In this study, we have exhibited how ways of conceptualizing "making" with respect to both established and emerging facilitation practices have been transformed in and through the work of design. Specifically, we have identified the concept of "constraints for creativity" and have shown how its meaning changed throughout the trajectory. We have also shown how different cultures of facilitation can be best characterized with respect to how the notion of an object or end-product is approached as an orienting feature in actual interactions (Jornet and Roth, 2018).

One of the main features of the approach exhibited here consists of a multi-level approach to learning and change. We have through our analyses shown how the aforementioned tensions manifest not only as abstract concepts but also as particular, individual ways of experiencing at the personal level (e.g. feeling tension between the need to give guidance towards producing a thing and the need to let children enjoy the creative process), while the same tensions also exist at the societal level (Engeström and Sannino, 2011). Connected to this, a general issue that emerged across the different phases in our data collection was the need for connecting constraints with children's experiences. In many ways this is a critical dilemma for educators working with children in makerspaces, that is to say, the need for structure and support while maintaining children's agency and sustained interest in making. Furthermore, it is a challenge to balance these concerns with institutional constraints.

We have explored models of making where we have built on arts and design-based play in kindergarten and from that introduced particular materials and tools for facilitating creative making. As we have demonstrated, whether such materials and tools become part of creative

making processes is very much dependent on the guidance and facilitation of adults, but these very practices are also part of the “makerspaces” phenomenon and need to be understood as concrete, historical processes inherent to the learning phenomena of interest. In this chapter we have reported findings from an investigation into what making for very young children might be, thus adding to existing “repertoires of practice” (Gutiérrez and Rogoff, 2003). Our findings most clearly show that maker practices, as these have developed in informal spaces through interest-driven activities, hold some promise for disrupting and changing formal educational practices, but making change on a larger scale requires systematic work over time.

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