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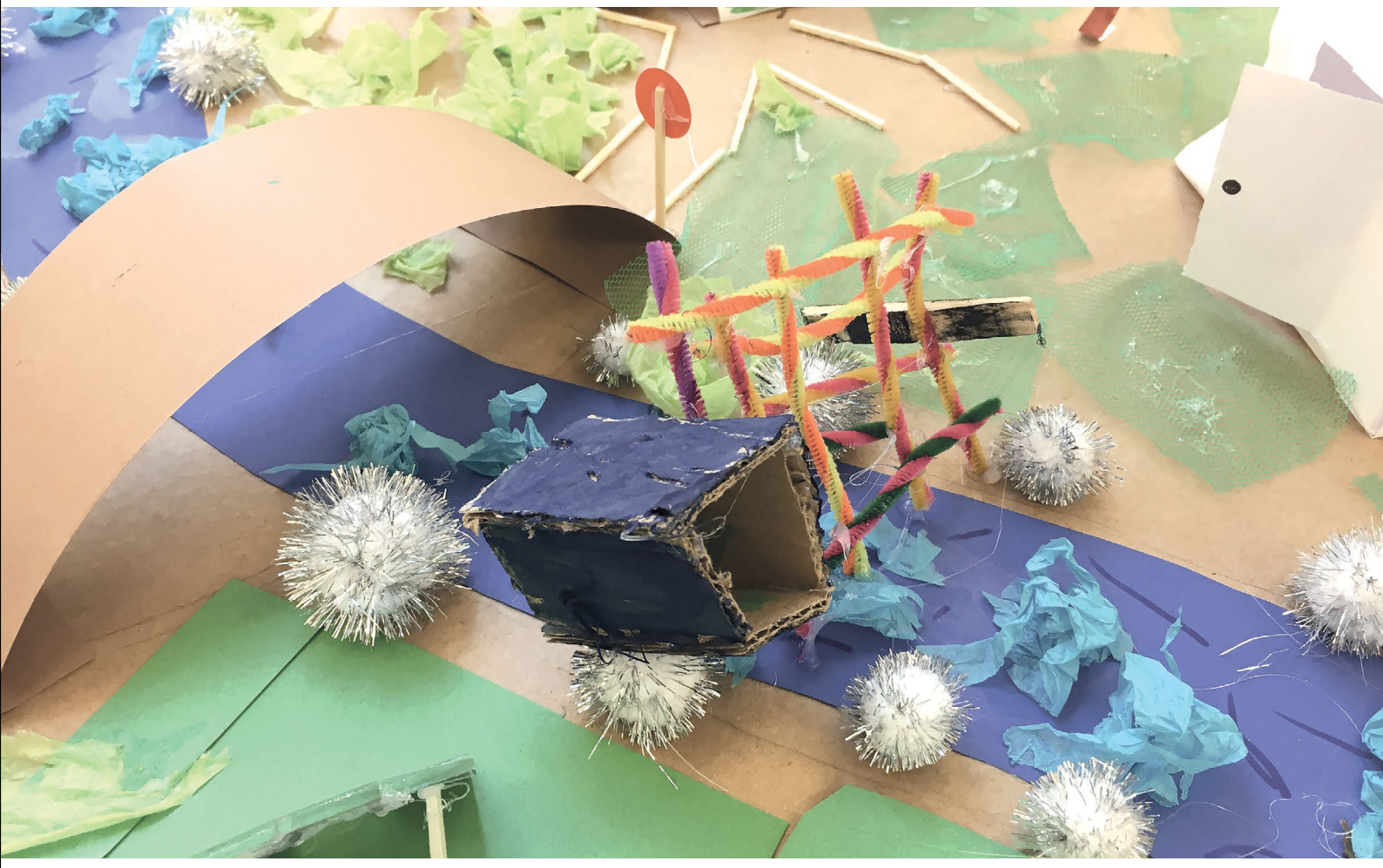
Lessons and stories about making, play, and collaboration from the Tufts-ISB Partnership



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Chapter 1. Makerspaces for Early Childhood Education (Principles of Space Redesign)

Amanda Strawhacker & Marina U. Bers

When the ISB Kindergarten teaching team wanted to involve their young children more in the Creator Space, the administration agreed that combining their emerging maker philosophy with the pedagogies of early childhood education was an exciting idea. However, Kindergarten teachers struggled to use the ISB's Creator Space, which to them felt "like a big-kid room" (M. Barbon, personal communication, January 2017). The storage is too high, tables and chairs are too tall, tools are too complex, and the room itself is too large and open for young children. Early childhood and makerspace education researchers from the Center for Engineering Education and Outreach and DevTech Research Groups (Tufts University) engaged in a collaborative project with the Pedagogy of Play research team at Project Zero (Harvard Graduate School of Education) and the Kindergarten teachers at ISB in order to design a d**evelopmentally appropriate Creator Space** for Kindergarten students at the school.

Much of the work of conceptualizing and designing the Kindergarten Creator Space (KCS) occurred through creating an experimental "sister space" at Tufts University, informed by ethnographic observations in ISB Kindergarten classrooms, Kindergarten play-sessions in the existing Creator Space, and one-on-one interviews with ISB Kindergarten teachers conducted by Tufts researchers (Bers, Strawhacker, & Vizner, 2018). The lessons learned from developing the space at Tufts were used to inform decisions about the construction of the ISB Kindergarten Creator Space. As this new space at ISB took shape, Kindergarten teachers were supported in different ways to promote their ownership of and enthusiasm about the space. This support came through experimental play-sessions with interested classrooms, as well as collaborative conversations within the Playful Classroom Environments Study Group, a working group of Kindergarten teachers facilitated by Project Zero, in which the teachers investigated playful learning settings through a participatory research process (Baker et al., 2016; Strawhacker, Tontsch, & Baker, 2017). Through these efforts, the space continues to evolve and serve the Kindergarten ISB community."

Makerspaces are a new concept for education, which promotes an emphasis on "learning-by-making," creating over consuming, and learner-directed projects (Honey & Kanter, 2013). We know that especially in early childhood (ages 3-6 years), children learn best by manipulating, building, and sharing physical creations, and by exploring new ideas with teachers and friends as guiding resources. Currently, there is very little research at the intersection of makerspaces and early childhood education. The DevTech Research Group, which focuses on developmentally appropriate

technology design and integration, has explored principles of Positive Technological Development in the context of traditional children's space design (Bers 2012; Bers, Strawhacker, & Vizner, 2018). In addition to research conducted in a diversity of school settings, play spaces, and museum settings, the authors, Professor Marina Bers and Ph.D. student Amanda Strawhacker, conducted research at ISB to learn more about how making and early childhood fit together (Bers, Strawhacker, & Vizner, 2018). Based on observations collected at ISB's Kindergarten classrooms, the authors identified a new set of general design principles and best practices for developing an early childhood makerspace that fosters making, creativity, and learning through exploration (see table 1). This new set of principles informed the design of the Kindergarten Creator Space at ISB. This chapter describes the principles in detail, as well as their practical application in space design. All images in this chapter come from the KCS at ISB.

Table 1.
Evidence-based Guidelines for Designing Early Childhood Makerspaces.

Principle	Example
1. **New technologies** should let children explore making with contemporary forms, tools, and ideas	Offer developmentally appropriate robotics, film-making equipment, or circuitry kits
2. **Materials** should be visible, accessible, and inviting	Store materials in glass jars or wire baskets on low, uncrowded shelves.
3. **Furnishings** should be child-sized and functional for children's needs	Adjust wood work tables to approximately 51cm height, use wide floor areas for work
4. Elements of the room should promote **exploration and risk**	Learn about and practice safe use of tools like hot glue guns and sharp knives
5. The space should **reflect the children** who use it	Display children's work and pictures at child-height
6. Facilitation and space design should **"say yes" to children**	Before telling children what not to do, learn why they are doing it
7. **Building and sharing ideas** is as important as the finished product	Let children make mistakes and test ideas instead of correcting

Figure 1
Children designing with KIBO.

Principle 1. New technologies should let children explore making with contemporary forms, tools, and ideas

The major difference that separates makerspaces from other learning environments is that they offer learners a way to engage with novel tools, technologies, practices, and forms of expression. There are many technologies available to children today, and many of them come from their parent's generation (like phones and pagers), their grandparent's generation (like LEGO bricks and polaroid cameras) and from many generations before that (like pencils and paper). However, a makerspace offers children a place where they can form their own community, and engage with the tools and skills that will become part of their own generation. Today, that includes programming, robotics, and engineering (Bers, 2008).

To serve this need, the ISB makerspace offers the screen-free KIBO robotics kit to engage children in developmentally appropriate coding experiences. Experiences with KIBO contribute to children's developing computational thinking. Computational thinking can be defined as a range of creative problem-solving and algorithmic strategies that comprise an expressive process to develop technological fluency (Bers, 2018). In 2016, Kindergarten children and teachers engaged in an intensive 2-week exploration of the KIBO robotics kit at ISB. This brief introduction sparked over a year of ongoing excitement and exploration with this developmentally appropriate robot kit. Young children have created working city maps with moving KIBO cars, built "cave explorer robots" using blankets and KIBO lightbulbs, and explored packaging and loading using KIBOs to transport plastic "grocery foods" across the makerspace. Currently, KIBO is a regular offering in the makerspace, and young children incorporate it into their engineering solutions, their models and experiments, and their free play in the space.

Figures 2 & 3
Materials are offered in baskets and boxes that can be easily moved, and laid openly on tables for children to play with.

Principle 2. Materials should be visible, accessible, and inviting

The first principle comes from long-standing early childhood pedagogy (e.g. Reggio Emilia and Montessori philosophies). Children, just like adults, enjoy working with beautiful objects and materials. Colorful materials, natural elements, and a variety of textures and sizes invite curiosity, and easy access to materials promotes a creative atmosphere (see figures 2 and 3). "Coziness" is already a popular Danish design concept involving soft, calm spaces that invite intimate social experiences. This kind of coziness is not just important for children's comfort, but also for their ability to focus. While many children can find it in themselves to give something a first try, it takes confidence to persist in the face of failure. Children's willingness to play and explore is inversely proportionate to their fear and safety-seeking reactions (Grossmann, Grossmann, Kindler, & Zimmermann, 2008). A space that is soothing, safe, and comfortable encourages children to persevere through disappointing moments, and to self-stimulate through creative and even challenging play. This adds to children's developing competence and perseverance in the face of many frustrations that can occur as they attempt to master new skills. In the KCS, this was implemented in the form of soft carpeting and cushions in the circle area, lots of wood details in the furniture, and a wide mirror near the light-filled windows. Children noticed these details as soon as they walked into the space for the first time, and many of them even exclaimed "it's so cozy in here!"

Principle 3. Furnishings should be child-sized and functional for children's needs

Just as materials can invite or discourage children, so too can furniture. One way to invite children to use furniture is to make it child-functional. Tables can be height-adjusted for the shortest setting (e.g. 51cm tall), and a variety of seating or standing options can create different comfortable options for children of all sizes. Similarly, the floor is one of the best workplaces for children, but a bare floor is not nearly as inviting as a cushioned or carpeted one. All ISB Kindergarten classrooms have a carpet, not just because it is comfortable, but because carpets indicate a gathering area to children. This is important for young children, who are still developing their collaboration and communication skills. The KCS includes familiar furnishings like carpet areas, low tables, and a variety of seating options to help children feel welcome (see figures 4 and 5).

Figures 4 & 5
Children sit cross-legged or on "bubble" seat, and use easy-to-reach storage baskets.

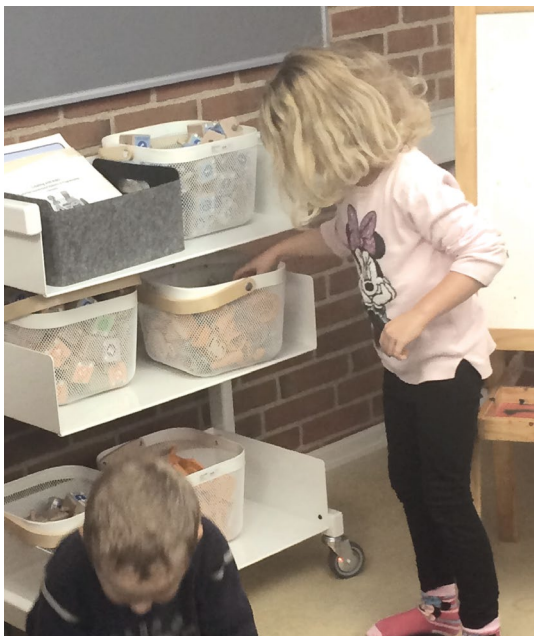

Figure 6
A boy uses a hot-glue gun to build a structure.

Principle 4. Elements of the room should promote exploration and risk

Makerspaces are unique learning spaces, because they put the learner in the position of collaborator, co-teacher, and self-motivated inventor. Children take these roles seriously and understand the responsibility they are being offered. In order to truly promote responsibility, facilitators can teach children how to use tools that require skill and care.

It's important here to point out the value of risk in learning experiences, especially as children's spaces (particularly in the US) have slowly become more sanitized of any potential risks or discomforts. While it's true that sometimes risks are unnecessary and potentially harmful (such as driving without a seatbelt), there are many learning experiences that simply cannot occur without a certain level of risk, and the absence of these experiences may even be harmful to children's development (Sandseter & Kennair, 2011). For example, tools like knives and hot glue guns have inherent risks and potential dangers such as injury. However, because it is impossible to remove the risk without also compromising the tool's effectiveness, children have a chance to learn about the responsibility associated with using them. In a sense, "danger" in a makerspace is not related to tools themselves, but rather to a lack of understanding or knowledge about how to safely use them. Similarly, "risks" are not preventable evils to be avoided, but real-world opportunities to explore safety and responsibility. For example, the boy in figure 6 (opposite page) was allowed to use the hot glue gun with help from a trained maker, and so learned about safe handling of hot tools. He also learned that he is a valued agent in the makerspace who is worthy of an adult's trust.

Children can benefit from working in a space that offers real responsibilities and risks. However, "risky" opportunities do not always have to be dangerous. Sometimes a risk for a child is as simple as trying to play with a new friend. To promote necessary multi-sensory and collaborative experiences that may require risk-taking, the KCS offers a diversity of unique materials for children to explore (such as delicate sculptures), as well as a variety of individual and shared making experiences (such as large building materials that allow more than one child to build).

Figure 7
A display of children's work alongside images of the maker, with captions of their own words.
Mette: "Look at this clay thing! Where did it come from? Is this his?" (gesturing to the picture)
Sara: "It's the same, the sculpture and the picture!"
Karl: "I know the boy in this picture! Look Max it's your brother!"

Principle 5. The space should reflect the children who use it

Putting children's work on display in the makerspace allows children to feel ownership of the room, and promotes community feeling for children who recognize their friends in the images.

Additionally, presenting work this way shows children that their creations are valued. When a group of children sitting at KCS carpet noticed a visual display at their eye level (see figure 7), they began a conversation.

The children not only recognize a unique creation, but they can even identify the maker and connect him to their own classroom community. "Museum-style" displays like this can communicate a lot about the work that happens in the KCS, even when the finished products do not stay constructed, such as with KIBO robots (see figure 8).

Principle 6. Facilitation and space design should "say yes" to children

Children have a hard time understanding things that they cannot see or touch, and much of what they can see from child-height is deliberately sized or stored in a way that makes it impossible for them to touch. Even young children know which tools and materials are "for little kids." Objects that are out of reach, shelving that is locked, and posted signs with lots of text all communicate "Off Limits" to children. By comparison, objects presented on tables or low shelves, stored in clear, open containers, and labelled with helpful images send a clear invitation to touch, play, and manipulate. Teachers came up with the concept of "saying yes to children" as a goal in their study group conversations with the Harvard PZ team, and brought it into their discussions of space design with Tufts researchers as well.

Another way to interpret this principle is by imagining ways to remove situations where teachers and facilitators have to say "No" to children. Teachers at ISB found that when they removed inappropriate tools and furnishings, they also removed opportunities for

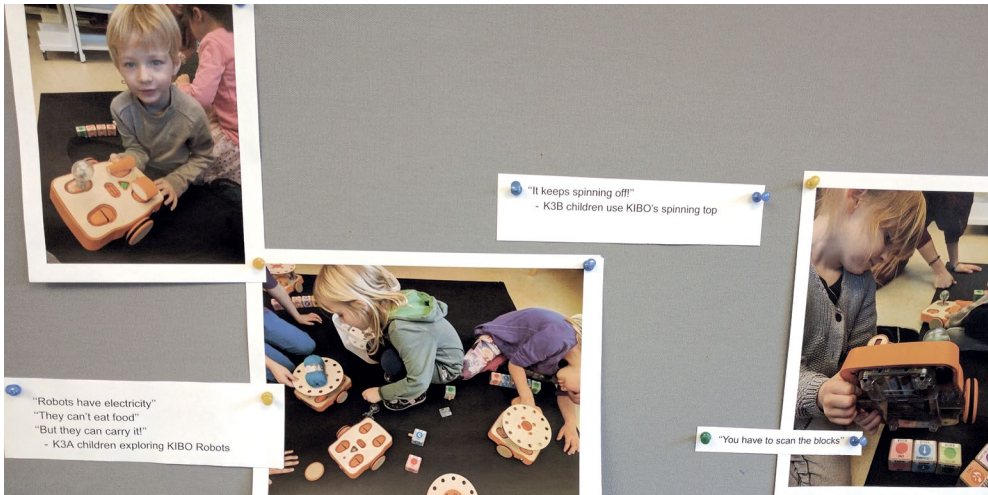

Figure 8
Museum-style display of children's work and written quotes demonstrate the work they have done in the KCS.

Figure 9
Seeking a dark place, children test KIBO light bulbs underneath a dangerous shelf.

children to "misbehave" by using the room incorrectly, and spent less time redirecting students. For example, three children who wanted to test the KIBO robot's light bulb began testing their robot underneath a tall, unsecured bookshelf (see figure 9). Their teacher correctly interpreted that, rather than trying to "break the rules," these kids just wanted a dark space for testing light bulbs. She knew that making a rule about avoiding the potentially dangerous bookshelf would only create a new problem (she now needs to police the bookshelf) without solving the first problem (children need a dark place to test). Instead, she created a dark place that was safe by adding blankets to the KCS. During their next visit, children chose to made a "dark cave" under a tall table to test the light bulb, which was much easier than crawling under the bookshelf (see figure 10). This is what is meant by providing a space that "says yes" to children: a space should naturally invite the kind of activity that is desired and allowed.

Principle 7. Building and sharing ideas is as important as the finished product

Although it is valuable for children to master skills and learn new tools, the most important lesson that children can learn in a makerspace is how to collaborate with friends, test ideas, and revise their work. For this to happen naturally, children may make dozens of failed attempts before creating something that "works." For example, a group of children requested to come to the KCS to build and test paper planes, a popular activity in their classroom (see figure 11). After 25 minutes of testing, researching directions online, and looking at a prebuilt model, they had made around 6 planes, and had iterated on each of them multiple times. They tested things like adding pieces of string to the planes "because it will be like the tail of a kite," and coloring the planes blue "so they will want to be up in the [blue] sky."

Figure 10
When given blankets, children constructed a "dark cave" to test KIBO light bulbs.

Although an educator could have stepped in to guide their ideas, the children were inspired and curious about seemingly illogical factors. Rather than interpreting this as a sign of misconceptions, this demonstrates the value of allowing children to make mistakes and learn from each other during the design process. By the end of the building session, children had discovered that one boy's plane always flew to the right. After testing everything they could think of, they eventually noticed the folds on his plane's wing. Without an educator's help, they made a new discovery about paper planes that they were excited to share with friends back in the classroom.

Taken together, these principles can serve as a guide for early childhood educators and administrators hoping to cultivate a strong makerspace and maker-mindset for young students. Using these principles, almost any space can be repurposed to be a "little kid space," supporting risk taking, exploration, innovation, and community building. Developmentally appropriate makerspaces can support creative learning in a way that is unique from and complementary to the learning that happens in the classroom and on the playground. In the next chapter, we discuss how we meaningfully engaged early childhood teachers at the ISB in the KCS, by supporting their own teaching values and goals for cultivating a maker community.

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Figure 11
Children explore many hypotheses about building paper airplanes.

Chapter 2: Maker values of early childhood educators, organizing a grassroots space

Amanda Strawhacker & Marina U. Bers

If we ask teachers in the same school, "What is the value of a makerspace for your students," would we get a clear answer? And would three different people have the same response? The question of why to introduce a makerspace is central to the development of any successful new makerspace project. This makes it surprising that few schools are able to answer it with certainty and clarity. A school's purpose and mission is usually well-articulated, such as the ISB's mission to "guide and stimulate children to become ambitious lifelong learners who achieve personal fulfilment and who will make positive contribution to our ever-changing world" (International School of Billund, 2013). Just as with a school, the identity of a space is driven by its purpose, and this identity also shapes a space's values. In the following chapter, we explore how ISB Kindergarten teachers set out to define the identity, purpose, and values of the new Kindergarten Creator Space.

When Camilla, the principal of ISB, told the Tufts research team that she wanted the Kindergarten teachers to have a Creator Space, she said that she only had one goal:

"I want the teachers to actually **use** it."

This was a very insightful goal. Our research has shown that in makerspaces that lack certain key elements, the space's expensive and promising equipment collects dust. One of the most important design elements for a makerspace is that it should have an "identity" before it is made. This means more than just knowing the audience, the scheduling, and the staffing for a space (although all of that is important). A space with an identity is designed with specific values in place to serve a specific purpose, such as a religious sanctuary or a sports stadium. A makerspace with no values is a space with no purpose, and a space with no purpose goes unused.

The DevTech Research Group at Tufts University, directed by Professor Marina Bers, focuses on designing, implementing, and evaluating new technological learning experiences for young children, including technology-rich spaces like makerspaces (Strawhacker, Portelance, Lee, & Bers, 2015). Professor Bers' framework for Positive Technological Development offers an approach for integrating digital experiences that can enhance children's learning, and their engagement with six positive behaviors associated with positive development: communication, collaboration, community building, content creation, creativity, and choices of conduct (Bers, 2012). DevTech researchers know how to design spaces to promote each of these positive developmental behaviors, and have designed an early childhood makerspace at Tufts University to illustrate that mission (Bers, Strawhacker & Vizner, 2018). However, the identity of that makerspace

Figure 1
Gaby, a lead Kindergarten teacher, selects pictures of makerspace activities that she thinks are the most important for children to experience.

is necessarily different than the identity of the Kindergarten Creator Space at ISB, because the ISB space must reflect the values and purpose of the school community there. DevTech's research offers a developmentally appropriate framework, which the Kindergarten teachers at ISB used to begin designing a makerspace with its own unique identity.

Researchers worked closely with the Kindergarten teaching team to identify their personal teaching values, so that they could plan for a successful Kindergarten Creator Space (KCS) together. Since makerspaces are still an emerging concept in education, there are many diverse values that educators might have when using them, including entrepreneurship, community service, technical expertise, self-expression, and more. Even among the makerspace researchers at Tufts, different individuals have unique personal views about the qualities and benefits of a "good" makerspace. Ph.D. student Amanda Strawhacker observed Kindergarten classrooms, attended teacher meetings, and interviewed lead teachers. All teachers participated in a card-sorting task developed at Tufts (Meehan, Gravel & Shapiro 2014) that helps teachers to identify their maker values (see figures 1 & 2).

In this task, Teachers looked at cards which listed many diverse values, learning outcomes, tools, and skills that could be associated with makerspace learning environments. These included items like "problem solving," "entrepreneurship," and "hot glue guns." They also viewed cards with pictures of activities that children might do in a makerspace, such as "building a community garden," "creating a model of a dream house," and "building and rehearsing a puppet show." For both sets of cards, teachers were asked to select the ones they found most meaningful to their teaching practice, and what they most would like to see their students doing in the KCS.

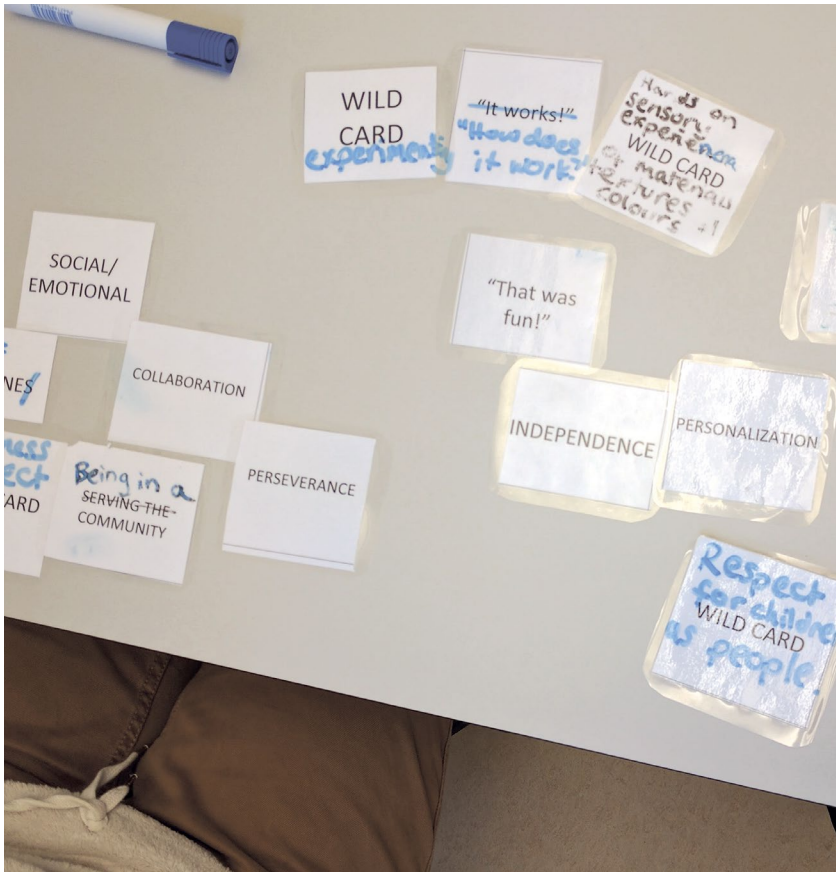

Figure 2
Ruth, another lead Kindergarten teacher, selected and organized these cards to represent her vision of important maker learning for 3-4 year olds in her room.

Selecting the cards was only a portion of task. Teachers discussed their choices with researchers, organizing cards in ways that made sense to them, and through their conversation, often arrived at a smaller subset of values that they felt very strongly about. For example, sometimes the cards reminded teachers of a vignette from their classroom that they considered a powerful learning moment, and which they would hold as a model for the kind of learning they'd hope to see in the KCS. Through these semi-structured interviews, teachers and researchers arrived at a deeper understanding of the true values and goals for the space.

Several core values emerged across the Kindergarten teaching team. Figure 3 shows the four main values of **sensory exploration, independence, social/emotional growth**, and **confidence**, along with practical examples of each that emerged in conversations and observations with teachers. While other makerspaces for older children or adults might focus on certain tools, skills, or finished products as part of their values (e.g. a makerspace specifically for woodworking), the KCS is unique in that its underlying values are almost entirely about making as a path toward social and personal development. This is perfectly appropriate for the 3-6 year age range of the KCS makers. At this age, children are still learning how to work together with others, how to persevere in independent work, and how to confidently continue to explore new interactions and ideas, even after a failure. In other words, children in the early years are learning how to be makers of community as well as makers of physical products.

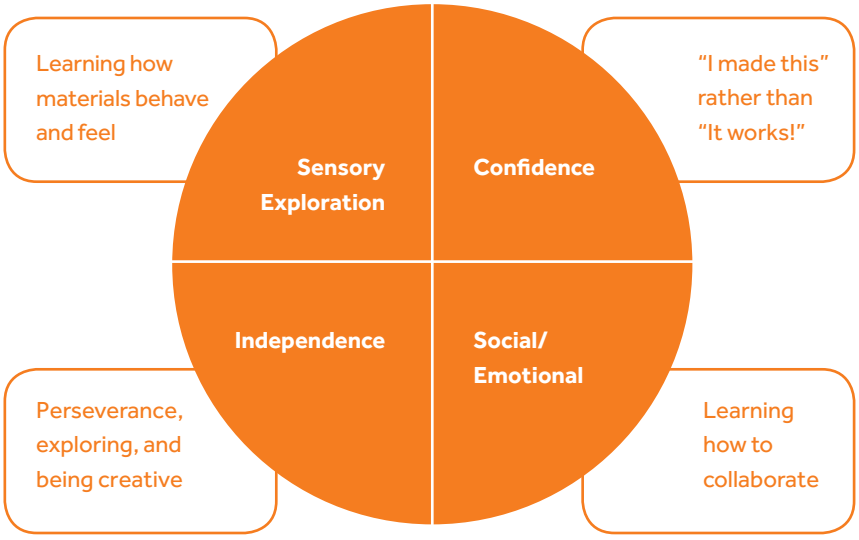

Figure 3
The four pie slices in this chart show the four key maker values that ISB Kindergarten teachers identified. The squares next to each pie slice offer more detail about each value.

These values all impacted the mission and design of the KCS, and the teachers clearly recognized the importance of knowing their values before using the room.

For example, Gaby said about the value of **social/ emotional growth**, "collaboration another skill that is important to have and I think it's not just in the children, but also in the room. We're three teachers there, so I think it's important that the children see how all the grownups also work together."

Ruth pointed out that specific tools and choices in the room can foster independence, saying, "there should be room for [the children] to try to solve problems themselves. For example, opportunities for them to choose which tool they think they might be able to use for a particular job."

Marina talked about the importance of changing the children's physical space to allow them more opportunities for **sensory exploration**: "it doesn't need to be fancy, but giving my kids some dark areas to test [the KIBO robot's] light, some small things to have KIBO carry, it's enough motivation for them to see if they can move things here, or see what happens if they put something upside-down there. I think it's more work to be responsive to them, but it's actually worth it because then you know what they like, what they want. They just need someone to listen to them."

With the values for the space clearly outlined, the plan for the KCS quickly became easy to implement. Since the values of the space are centered around individual confidence and social development, the logical purpose of the space is to offer a range of inviting, functional spaces for children to practice working alone, in pairs, or in groups to develop their social interaction skills. To serve this goal, we filled the space with a carpeted "group" area, work table spaces for individual work, and larger building materials (like bubble chairs and cardboard boxes) that require children to work in pairs or small groups to use. Additionally, the identity of the space as a distinct location within the school soon emerged, as a space for young children at ISB to grow and learn about themselves and others by engaging in unique, exploratory building and making experiences. For example, unique materials and activities such as foot painting and large-scale building, typically more difficult to implement in the classroom, are perfect sensory activities for the makerspace, and the space is outfitted with those materials.

Now that the identity, purpose, and values of the Kindergarten Creator Space have emerged, what is the result of this project in addressing Camilla's main desire, that the space be regularly used? In support of our hypothesis that a space with an identity can foster a community, we're pleased to say that the makerspace is regularly used by the Kindergarten classes. Marina has even said, "We've got a room! And it's not like yeah, we got a room and we're done – no, we're cat fighting for time in it!" After the makerspace was opened, Camilla wrote in the school's newsletter, "the Kindergarten Creator Space (KGCS) is a hit! The K teachers and children are working hard to care for and maintain the space."

The cards in this example offered a structure to facilitate conversations among ISB Kindergarten teachers, conversations that were critical to designing a successful learning space. The ISB's space is uniquely its own, but this kind of work could be successful in any school setting. The richness of identifying these values can come from any reflective conversation among teachers, administrators, or other stakeholders involved in the design of a new space.

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