Design& Diarrhea

An evidence-based design process for childhood health outcomes in rural Zimbabwe

DESIGN & DIARRHEA
AN EVIDENCE-BASED DESIGN PROCESS FOR CHILDHOOD HEALTH OUTCOMES IN RURAL ZIMBABWE

A Thesis
Presented to the Faculty of the Graduate School
of Cornell University
In Partial Fulfillment of the Requirements for the Degree of
Master of Arts

by
Brianna Marie Reid
August 2013

Abstract

Design & Diarrhea

An evidence-based design process for childhood health outcomes in rural Zimbabwe

There is scarce research and programmatic evidence on the effect of poor water, sanitation and hygiene (WASH) conditions of the physical environment on early child cognitive, sensory-motor, and socio-emotional development. Furthermore, many common WASH interventions are not designed to protect babies in the first 3 years of life. This thesis reviews evidence linking WASH, anemia and child growth, and highlights pathways through which WASH may affect early child development through inflammation, stunting and anemia. This project seeks to demonstrate the contribution that appropriate, evidence-based designed environmental interventions can make within a broader system of nutritional and health interventions. Emphasis is placed on the design process employed by examining that process as a cross-disciplinary approach to addressing a serious threat to childhood health and development worldwide.

Biographical Sketch

Brie Marie Reid

The author is most passionate about the ecology of children's environments and the full spectrum of childhood experience. She received her Bachelor of Science in Design from the Department of Design and Environmental Analysis at Cornell University in 2012. Her previous research focused on human development and play with regards to the design of children's museum exhibit spaces as well as the efficacy of infographics as a design and communication strategy.

This thesis reflects her pursuit of a Master of Arts in Design with a concentration in Special Populations and a minor in Human Development as well as a partnership with the department of Global Health. Her ongoing research focuses on human development with regards to the design of children's spaces in under-served communities. She currently seeks projects that fall within the intersection of research-based, community-engaged design for children in need.

Acknowledgments

There are no words to express my gratitude to the army of support that I've garnered for this project and over the years. Special thanks goes to my friends Gretchen, Alex, and Diana who all provided not only their company but also their expertise along with many helping hands late at night when thesis projects seem most overwhelming. I would warmly like to thank my entire family for their excitement (if not their understanding) through the duration of my studies. I also owe a tremendous amount of thanks to John Stager and the entire facilities team at the College of Human Ecology who suffered through my endless prototyping with a smile and a joke every day.

I would like to profoundly thank Paul Eshelman for his role as my Committee Chairperson and especially for his invaluable guidance, endless hours of encouragement, and especially his generous compassion to myself and the design's future users. Sincere gratitude is due to Gary Evans for his suggestions, references, and support. Thanks is also due to Rebecca Stoltzfus and the entire Zvitambo and SHINE team for taking a chance on my skills as a design student as well as their warm welcome, continued support, and inspirational goals.

Thanks to everyone for giving me your support and encouragement, as well as sharing my tears, joy, anger, and achievements.

Table of Contents

List of Figures

List of Tables


INTROD

Chapter 1

UCTION

Section One

An Overview

Introduction

Infants and young children in low-income countries are at risk of disease because their natural exploratory behavior leads them to eat soil and poultry feces full of bacteria. Chronic ingestion of microbes inflames the lining of the small intestine, rendering it unable to absorb critical nutrients. Children experience frequent diarrhea from these exposures, but diarrhea is an expression of an underlying disease rather than the disease itself. Recent evidence suggests that this behavior harms growth and development due to interference with regular digestive processes. Rather than using energy for growth, the inflammation directs the child's energy towards fighting off infection. These processes contribute to malnourishment, stunting, and potentially anemia: all risk factors for deficits in early child development (Walker et al., 2007).

While many water, sanitation, and hygiene (WASH) interventions are in place for adults, these interventions are not designed to protect babies during their critical growth periods. Formative research has revealed a critical need to reduce babies' exposure to environmental contamination in rural Zimbabwe. This thesis describes and evaluates the process of developing a culturally appropriate protective play space within the framework of a large sanitation & hygiene and nutrition interventions (SHINE) trial. The results of SHINE will be widely disseminated to the global health community, with an impact on child health interventions in Zimbabwe and globally.

This project focuses on assessing a human-centered, environmental design process to reduce the risks of stunting and anemia in rural Zimbabwean homesteads. This kind of design is crucial because children have heightened sensory needs, special scale considerations, and a totally different way of moving through and perceiving space as compared to adults. At a very young age, everything is new as infants and toddlers filter and interpret sensory information. Research on early childhood development helps to inform design that spotlights these unique needs. Children are smaller and grow at a rapid pace, making anthropometric information necessary for spaces that are not intended for adults. Human centered design also emphasizes the value of understanding the ways cultural and neurobiological contexts affect the suitability of play environments. Ultimately, young children are a group of users who have little direct control over the environment. The designer is responsible not only to educate him or herself on the varied needs of children as they grow and develop, but is also responsible for integrating past research with present community values. Each designer must strive for decisions that are ethical, sustainable, and informed. A social, human-centered and evidence-based design process examines the needs and behaviors of the users through what is desirable, feasible, and logistically viable. These lenses help designers, stakeholders, and users work together to come up with meaningful solutions.

This first chapter introduces the design challenge at hand by providing background on malnourishment in young children within the context of rural Zimbabwe. It also touches on the need for a vigorous, multi-disciplinary approach and in studying the role that design can play in a large-scale nutrition research project in an economically developing country.

The literature review affords a deeper look into the forces that shape children's early experiences. Growth is a complex result of interplay between the child's body, diet, family life, security, neighborhood, peers, community, access to information, and physical environment. The second section therefore highlights the ecology of children's environments and a culturally-specific spectrum of childhood experience. Design guidelines generated from research provide a structure for future evidence-based design.

The third section focuses on the project's methodology in order to translate concrete pieces of knowledge gleaned from prior sections into themes, frameworks, opportunities, solutions, and prototypes. This phase moves back and forth between concrete solutions and abstract ideas to develop prototypes.

The fourth section is the sum of the results of the previous sections for the final phase of design development. This will realize solutions through design assessment and implementation so that the final solution is ready for integration into a larger malnutrition intervention research project. In advocating a deeper relationship between design and science, there is a real need to study the impact of design and disseminate what is learned.

Finally, the discussion section will take a critical look at the design process and results. This section engages public health and nutrition researcher with knowledge of the larger project's context to comment on the thoroughness and relevance of the design guidelines and the design as a response to the guidelines. The discussion section will also take a reflective look at the insights and pitfalls of the process and project overall.

This project seeks to demonstrate the contribution appropriately designed environmental interventions can make within a broader system of nutritional and health interventions. Emphasis is placed on the design process employed by examining that process as a cross-disciplinary approach to addressing a serious threat to childhood health and development worldwide.

Section Two

The Design Challenge

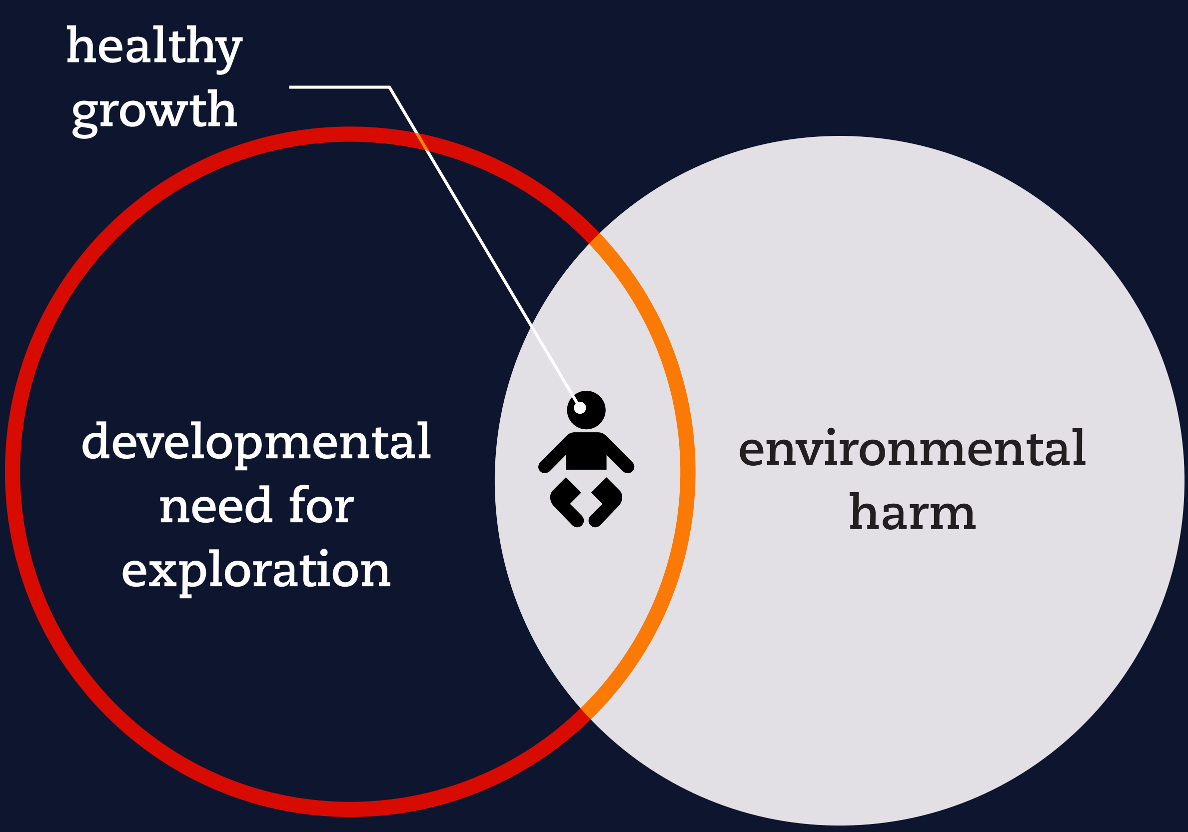


Figure 1-1: Diagram of the basic design challenge.

How might we reduce childhood mortality & morbidity?

In 2011, more than 25% of children under 5 years of age were stunted – roughly 165 million children globally. Sub-Saharan Africa and South Asia are home to 75% of the world's stunted children.

- Unicef Nutrition Report 2013

Despite considerable measures taken on a global scale to improve maternal and child health, significant challenges continue to disproportionately affect children in resource-limited settings ("The Millenium Development Goals Report 2012," 2012). Children born into poverty are almost twice as likely to die before the age of five as those from wealthier families. Mortality is also more likely to strike children in rural areas. Poor growth during infancy and early childhood remains an important risk factor for childhood morbidity and mortality. It is also a major public health challenge in low and middle-income countries. Approximately 35% of child deaths are attributed to sub-par nutrition. An estimated 200 million children under five in low and middle-income countries are at a risk of not achieving their full developmental potential in part due to undernutrition (Grantham-McGregor et al., 2007).

Chronic malnutrition and iron-deficiency anemia are key risk factors for poor cognitive, motor and socio-emotional development (Prado & Dewey, 2012). Iron deficiency may also affect brain development through hypo-myelination and impaired neurotransmission (Lozoff et al., 1998). Anemic infants in Costa Rica were easily tired, hesitant and less attentive, playful and exploratory of their environment (Lozoff et al., 1998).

Chronic malnutrition, or stunting, is a form of growth failure that occurs over time. A child who is stunted or chronically malnourished often appears to be normally proportioned but is actually shorter than normal for his or her age. Childhood stunting is also a risk factor for diminished survival, short adult height, impaired intellectual development, reduced economic productivity and low offspring birth weight. Longitudinal studies have demonstrated deficits in cognition and school achievement from 4 to 19 years of age in children who were anemic in their first two years of life (Lozoff & Georgieff, 2006; Lozoff, Jimenez, & Smith, 2006). Stunted children in the first two years of life continued to show deficits in cognition and school achievements from age of 5 years to adolescence (Grantham-McGregor et al., 2007). Stunting at 24 months was associated with a 0.9 year reduction in schooling, delay in school enrollment, and a 16% increased risk of failing at least one grade in school (Martorell, Melgar, Maluccio, Stein, & Rivera, 2010). Put simply, stunted or undernourished children perform worse than healthy peers in cognitive and motor tasks and in school achievement (Grantham-McGregor et al., 2007).

Under-nutrition affects physical growth, motor development, and physical activity, which may in turn influence brain development through both caregiver behavior and child interaction with the environment (Levitsky & Barnes, 1972). These risk factors affect children profoundly at very young ages. Current research suggests that the window of opportunity for preventing undernutrition ends at 2 years of age. Adequate nutrition during pregnancy and the first two years (1000 days) of life is necessary for normal brain development. Brain development during this period lays the foundation for future cognitive and social ability, school success, and productivity (Prado & Dewey, 2012). The key, then, is to focus on interventions to mitigate these risk factors.

Environmental Enteropathy: the underlying issue

While rigorous dietary interventions have mitigated some effects of stunting, they haven't closed the growth gap in children from low-income contexts (Dewey & Adu-Afarwuah, 2008). In a recent review of thirty-eight studies on nutrient-dense foods and supplements, nutrition education, and behavior-change interventions reduced only about one third of the average growth deficit in Asian and African children. This isn't to say nutrition interventions are not useful. In a large-scale nutrition supplementation program in Guatemala, the provision of a high energy and protein supplement during the first three years of life resulted in increased height gain, improvements in intellectual performance at eleven to twenty-six years of age, and improvements in reading and intelligence comprehension at twenty-six to forty-two years of age (Ramirez-Zea, Melgar, & Rivera, 2010). However, with many Asian and African children's heights and weights still a z-score below those of their healthy peers, nutrition doesn't paint a complete picture.

An emerging hypothesis suggests that a major cause of child undernutrition is a subclinical condition of the small intestine called environmental enteropathy. This condition decreases the small intestine's ability to absorb nutrients, so the child's body diverts a large amount of energy towards fighting off the infection rather than towards growth. Environmental enteropathy is characterized by reduced intestinal barrier function and chronic systemic inflammation. Research in Gambia showed that 43% of linear growth failure could be explained by indicators of environmental enteropathy. These characteristics may be an important cause of poor growth in children (Engle et al., 2011).

The precise cause of environmental enteropathy is unknown, but it has been linked to unsanitary and unhygienic living conditions and long-term exposure to fecal pathogens. Common sources of exposure to fecal pathogens include contaminated water, contaminated food, poor sewage treatment, houseflies, and poor or absent cleaning. These pathways of fecal-oral transmission have been described for decades using the "F Diagram" (food, flies, fingers, field and fluids) (Grantham-McGregor et al.,

INFANTS' & TODDLERS' VERSION OF THE F-DIAGRAM

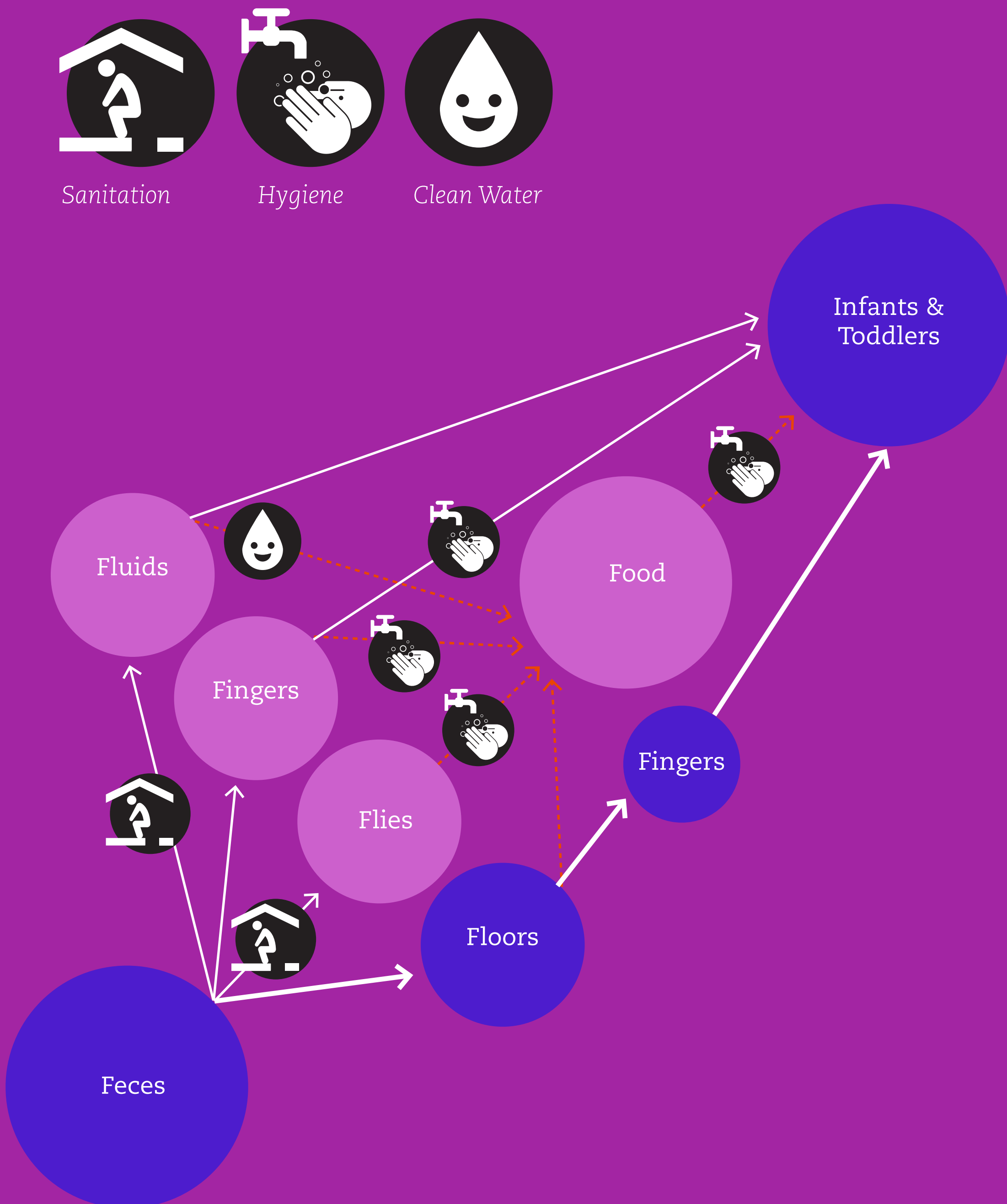


Figure 1-2: The physical environment and development

2007). However, the primary routes of transmission may be different for infants and young children because their primary food and fluid is breast milk (Figure 1-2). Typical sanitation and hygiene methods such as latrines and hand-washing do not adequately protect infants from sources of contamination because of the time they spend prone on the ground. Infants regularly mouth objects in their environment as part of normal development.

In developing countries, young children crawl and play in areas with soil that is contaminated with human and animal feces. In Lima, Peru, an in-depth behavioral observation reported that children under five ingested an average of 3.9 mouthfuls of chicken feces during a twelve hour period (Marquis et al., 1990). A recent review reported that human consumption of earth is common among children and pregnant women in low-income countries, where pathogen density is highest. Unsurprisingly, environmental enteropathy is common among infants in low income countries and has been proposed as a major pathway to childhood stunting (Walker et al., 2007).

The danger of environmental enteropathy is increasingly salient in Zimbabwe. During early research to inform infant growth interventions, a project cohort looked to identify the major pathways of fecal-oral microbial transmission among infants in rural Zimbabwe. The study began with observation of infants and their caregivers to identify the frequency of objects put into infants' mouths (whether swallowed or not) and the presence of visible dirt over a six hour period per household. The study then focused on sampling and microbiological analysis of the objects that were mouthed most frequently and/or were visibly the dirtiest. Soil samples were collected from three parts of the yard where children were most likely to play. Parts of the yard such as areas used for laundry, nappy changing, bathing, cooking, or and the areas near the rubbish pit were also likely sources of feces-contaminated soil either from human contamination or from chicken feces contamination. The study revealed that infants in rural Zimbabwe are frequently exposed to bacteria (such as E.coli) indicating the presence of fecal matter through daily activities (Ngure, 2012). Therefore, rural Zimbabwean homesteads serve as a context to develop an effective intervention to combat childhood stunting and anemia and test the environmental enteropathy hypothesis.

Infants, environmental enteropathy, and a protected playspace

A significant insight gleaned from the Zimbabwe microbe study was that existing water, sanitation, and hygiene (WASH) interventions fail to protect infants from ingesting soil and feces. WASH interventions to date have focused on hand-washing, improved drinking water sources, water treatment, and improved sanitation. Little attention has been given to infants' exploratory ingestion of soil and chicken feces. These exposures place infants at risk of developing environmental enteropathy and could contribute to stunting and anemia (Ngure, 2012).

This raises the need for effective interventions designed to break this prominent route of infant fecal-oral transmission. While safe feces disposal is critical in preventing pathogenic bacteria from reaching children's hands and mouths (Pollitt, Gorman, Engle, Rivera, & Martorell, 1995), more attention should be devoted to interventions aimed at reducing animal fecal contamination of children's environments. One such intervention is educating mothers on personal and environmental hygiene and the safe disposal of human and animal feces to reduce fecal-oral transmission. Another intervention involves a clear separation of the infant from contaminated soil without negating the child's physical and cognitive development.

Other locations in Peru and Bangladesh have also arrived at the issue of chicken feces in infant play areas. A study in Peru developed a physical and education intervention to encourage participants to corral their chickens to reduce the spread of chicken feces but local methods of chicken husbandry made this practice difficult to implement effectively (Harvey et. al., 2003). Raising poultry at home is common in many Peruvian communities in low-income countries, but evidence on the socioeconomic acceptability of corralling is lacking. Most participants in the Peruvian study shut their birds in provisional enclosures at night, but most stated that birds are healthier, happier, and produce better meat and eggs when let loose by day. After extensive education and assistance, participants were willing to corral birds more often but many kept the birds penned only intermittently due to perceived disadvantages. Similar to the rural context in Zimbabwe, the additional costs of feeding and watering poultry were a significant obstacle for some families. The practice of free-range chickens is more economical to families. Additionally, developing a secure, acceptable, and affordable corral that would not be misappropriated to different uses remains a challenge in both populations. This project therefore focuses on a protective playspace that would neither interfere with current agriculture practices nor inconvenience families greatly. Education about disease will trigger behavior change motivators for caregivers as they are interested in the health and well-being of their children. By tapping into caregivers' nurturing interests, families and communities may be more receptive to an object for their children rather than for their chickens.

Rural Zimbabwean mothers perceive that nothing can be done about their children's exposure to contaminated soil, given babies' natural need to explore their environments and the simple conditions in which the families live. The initial reaction of Zimbabwean parents to American play-yard products was negative, because they believe that babies must explore their environments as part of their natural development. Subsequent focus group discussions and structured interviews with mothers and fathers revealed that parents were initially resistant to the concept of confining their children to a protective area. Parents felt that such confinement was worse for a baby's development than ingestion of contaminated soil. However, after locally-designed behavior change communication about the dangers of ingesting soil and chicken feces on infant health, local attitudes shifted and became positive to the idea of protecting infants from soil and chickens. Parents expressed interest in owning a protective playspace, if it could address the cultural and developmental needs of their children (Zvitambo, unpublished).

This project describes the process of developing and implementing a culturally appropriate protective play space intervention for a larger research trial designed to measure the independent and combined effects of WASH and infant feeding interventions on child growth and anemia in rural Zimbabwe (SHINE). This project uses human-centered design methodology to create and assess the playspace prototype before full-scale implementation. No research study has yet met the challenge of protecting crawling and toddling babies from the hazard of contaminated floors and yards in a rural developing nation.

Conclusion

While no research study or design intervention has yet addressed the need to protect crawling and toddling babies from contaminated floors and yards in a rural developing nation, there are design precedents that can help define critical facets of the problem. As problem definition is one of the first steps in the design process, problem understanding is a crucial part of design problem solving (Casakin & Kreitler, 2005). Studies in areas such as physics, mathematics, and history also demonstrate that experts first seek to develop an understanding of problems, and this often involves thinking in terms of core concepts or big ideas (Bransford, Brown, & Cocking, 2000).

This project's first and foremost problem is creating an environment free of fecal bacteria for infants and toddlers. Additionally, designing in a holistic way requires identifying multiple facets of the design problem. While American-made play-yards could accomplish the primary goal of a fecal barrier, they fail to address a myriad array of other needs. From a logistical standpoint, American play-yards are too expensive to purchase on a large scale, and manufacturing and distributing 2,100 protective playspaces for the rugged Zimbabwean landscape is no small task. Materiality has many implications in terms of durability, weight, sustainability, and cost. The physical intervention needs to be designed with the contexts of the infants' environment, culture, and developmental processes in order to be an appropriate solution. This requires understanding the nature of play and how play environments contribute to early childhood motor, neurological, and social development. Furthermore, any play environment exists in the context of a larger Zimbabwean culture, the local community, and family structures. While infants are one user, their mothers, caregivers, and sibling peers are compelling users that make the intervention either a success or a failure based on their usage of it. Village health workers and Zimbabwean researchers are users in that they will be introducing and distributing protective playspaces. Pinpointing and catering to the viewpoints of multiple stakeholders is a crucial and difficult aspect of the design process.

The challenges present in this project all call attention to the efficacy of a multidisciplinary team of community members and experts alike. The problems and possibilities within children's environments demand creativity, ingenuity, responsibility, and compassion to provide supportive spaces for growth.


LITER
REV

Chapter 2

ATURE IEW

Section One

Neurobiological Development

The first two years: a critical window of development

"There are three teachers of children: adults, other children, and their physical environment."

– Loris Malaguzzi

Because the protective playspace directly impacts child development, it is critical to analyze multiple aspects of the child's immediate environment as it relates to mental and physical growth. Child development refers to the ordered emergence of interdependent skills of sensory-motor, cognitive-language and social-emotional functioning (UNICEF, 2006). It is a complex phenomenon that is dependent on biological factors (such as nutrition), genetic factors, children's experiences and caregiver-child interactions.

As noted earlier, biological and nutritional risk factors associated with poverty lead to inequalities in early child development. These inequalities, in turn, undermine educational attainment and adult productivity, and contribute to intergenerational poverty (Engle et al., 2007). Risk exposure begins in early life and leads to widening disparities and slower developmental trajectories that become more established as the child grows (Walker et al., 2007). Even after several decades of nutrition and health interventions, childhood stunting and developmental impairment remain pervasive in low- and middle-income countries. Play spaces must also be attuned to the developmental needs of children in addition to nutrition and sanitation needs.

A main activity in early childhood is, somewhat obviously, play. Quality play at young ages is a prelude to positive functioning later on in development. Many studies, as early as Piaget (1962) and Vygotsky (1978), have explored the connection between play and child development in cognition, language and literacy, social, physical, and emotional development. Studies by Bodrova and Leong (2003) show a direct link between play in young children and memory, school adjustment, oral language development, and improved social skills. The power of play is evident in its effect on imaginative and creative problem solving, identity, and self-expression. In fact, evolutionary biologists have noted that playing is one of only three behavioral ways in which primates are evolutionarily superior to reptiles (nursing and audio vocal communication are the other two) (Gore & Gore, 2003).

Play and development go hand-in-hand. Play, in and of itself, supports the total development – social, cognitive, affective, emotional, and physical – of all children (Johnson, Christie, & Wardle, 2005). This can be understood from a few different perspectives. First, play activities strengthen neural networks and contribute directly to the biological structure of the brain. Second, play involves children interacting with their environment in physical and social ways, so play is a direct connection to children's physical and mental well-being. Third, play is interactive. The child responds to his or her environment and vice versa. This environment is not only the physical environment but also the community and culture in which the child is raised, so play provides concepts integral to developing as a member of the child's society. This thesis integrates three theories of play and child development to better understand the forces at work in the ecology of children's environments as well as to fully appreciate the nuanced and pivotal role of the first two years of human development. The first of these theories looks at development through a neurobiological perspective, which involves understanding how the body and brain create emotions, memories, and sensory experiences. The second theory, the bioecological perspective, takes a more holistic view of child development as a function of multiple internal and external systems in a child's life. Finally, the third theory dives deeper into culture as an inherent system of child development. All theories and perspectives will be explored through the over-arching lens of play and play spaces.

Neurobiological Views of Early Childhood Development & Play

Brain Development

From birth, a child's mind is primed for ingesting and processing new information. At birth, the brain is nearer to its adult size than any other physical structure and continues to grow at a rapid pace throughout infancy and toddlerhood. This intense period of growth is best understood by looking both at brain development at the microscopic cell level and brain development in the cerebral cortex. On a microscopic level, information is processed through complex workings of brain cells and the connections between the cells, called synapses. Most of the synaptic connections develop before birth and during the first three years of life to form a complex neural network, shown in Figure 2-2 (Laura E Berk, Mann, & Ogan, 2006).

In the first thirty-six months of life the average child experiences so much mental stimulation that his or her brain makes approximately one quadrillion synaptic connections (Huttenlocher, Vasilyeva, Cymerman, & Levine, 2002; Moore & Persaud, 2008). Gains in neural fibers and myelination connections cause the brain to grow from nearly 30% of its adult weight at birth to 70% of its adult weight by age two (Knickmeyer et al., 2008). After age three, the number of synapses drops as the brain undergoes a pruning process to increase the quality of synaptic connections. As neurons form connections, stimulation becomes vital to their survival. The connections that are used in early childhood are strengthened while those that are not used are eventually eliminated.

The hub of intense neural growth is the cerebral cortex, a walnut-shaped structure that surrounds the rest of the brain. The cerebral cortex is the largest brain structure - it accounts for 85% of the brain's weight and contains the greatest number of neurons and synapses. It it also the last part of the brain to stop growing, so it is sensitive to environmental influences for a much longer period than any other part of the brain. As a child grows and develops, his or her newfound skills follow the order in which their cortical regions develop. Figure 2-3 shows the specific functions of regions of the cerebral cortex. A burst of synaptic growth occurs in the auditory and visual cortices and in areas responsible for body movement over the first year. These bursts of growth correspond with a time of dramatic development in auditory perception, visual perception, and the

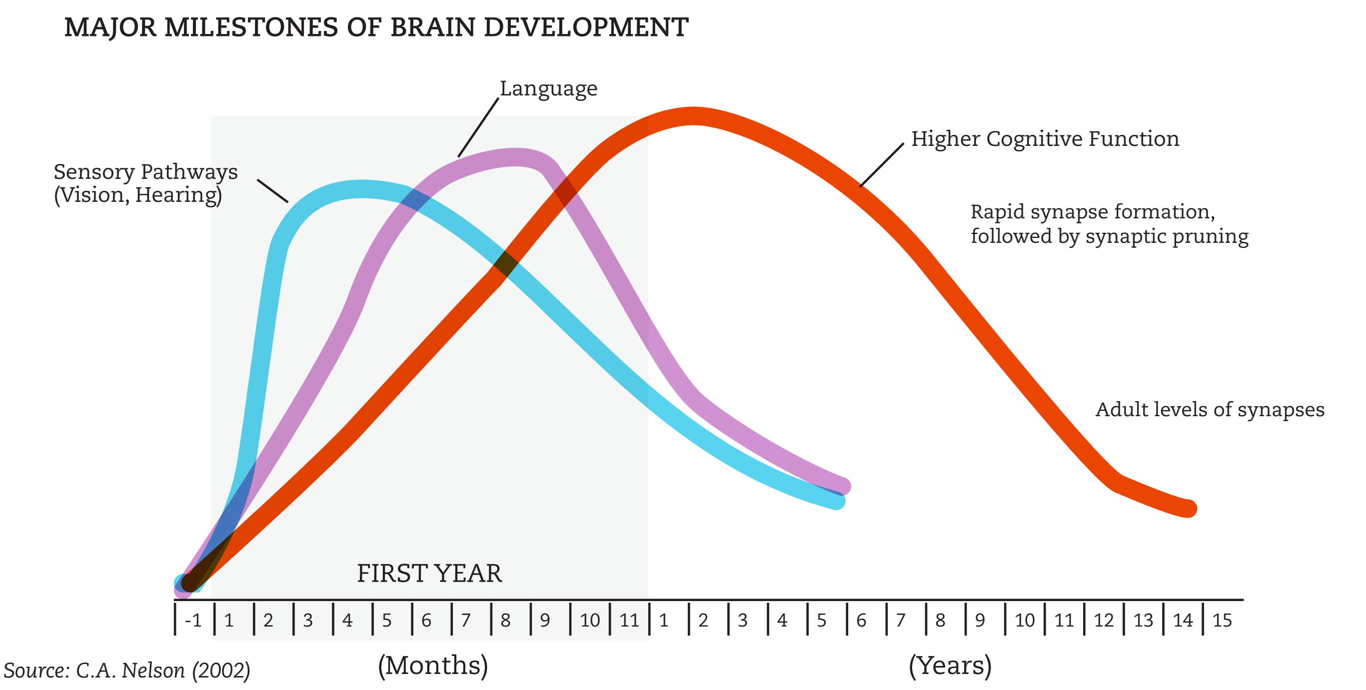


Figure 2-2: Synaptic development.(Johnson, 2005)

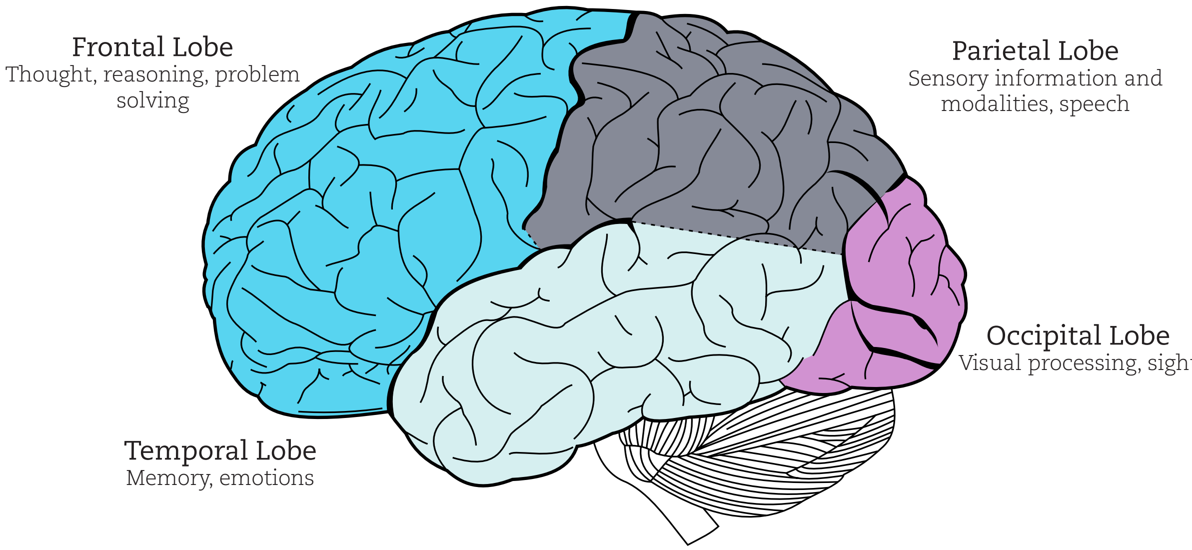


Figure 2-3: Left side of the cerebral cortex, adapted from Grey's Anatomy.

child's mastery of motor skills (Johnson, 2005) The region with the most extended period of development is the frontal lobe, responsible for thought, consciousness, inhibition of impulses, integration of information, use of memory, reasoning, and problem solving. Exploration and experience greatly influence the rate and success of the cerebral cortex's organization (Laura E. Berk, 2012). A highly plastic cerebral cortex, in which many areas are not yet committed to specific functions, has a high capacity for learning. The brain is more plastic during the first few years than it ever will be again due to an overabundance of synaptic connections supporting brain plasticity and children's ability to learn.

Studies confirm that sensitive periods in brain development exist, and that the general quality of the environment affects overall brain growth. When animals are reared from birth in physically and socially stimulating surroundings and compared with those reared in deprived and isolated environments, the brains of the stimulated animals show many more synaptic connections (Greenough & Black, 1992). Studies of infants placed in orphanages confirm the importance of a stimulating environment for development. Researchers followed the progress of a large sample of children transferred between birth and 3 ½ years from extremely deprived Romanian orphanages to adoptive families in Great Britain (Beckett et al., 2006; O'Connor, Rutter, Beckett, Keaveney, & Kreppner, 2000; Rutter, 1998; Rutter & O'Connor, 2004; Rutter et al., 2010). Initially, most children were impaired in all aspects of development. While cognitive "catch-up" was impressive for children adopted before 6 months, children who had been institutionalized for longer than their first 6 months showed serious intellectual deficits. Most of the children also displayed at least three serious mental health problems such as inattention, over-activity, unruly behavior, and social disinterest (Kreppner et al., 2010). A major correlate of both time spent in the institution and poor cognitive and emotional functioning is below-average head size, suggesting that early lack of stimulation permanently damages the brain (Sonuga-Barke, Schlotz, & Kreppner, 2010).

The neurobiological perspective (Shore, 1997) highlights the importance of the environmental impact of nourishment, stimulation, and responsiveness on the brain. Play mediates brain development first through the creation of synapses and then by the formation of more complex neural structures as the child's play experiences shape further brain development. Data from advances in brain scanning have provided new insights in learning and development. For instance, when children play, they activate the neocortex and the amygdala, or the thinking center and emotional center of the brain, respectively. Strengthening the connections between these centers improve behaviors involving cognition and emotion like problem solving and creative thinking (Laura E Berk et al., 2006). Children need to play and explore to construct the richest possible set of synapses. This forms the foundation for future brain development.

Understanding the relationship between play and brain development is important when seeking to understand how environmental factors can influence it. Play reflects development because it serves as a window on brain development and suggests the current developmental status of the child. Play reinforces development because it serves as a context and medium for the expression of development and provides opportunities for continued learning. Play also results in development because it can generate qualitative improvement in the brain's functioning and structural organization (J. E. Johnson, Christie, & Wardle, 2005). As children within impoverished communities continue to struggle to meet developmental milestones, understanding and designing for play becomes a significant goal. This neurobiological review traces the development of short-term and long-term play behaviors from four basic dimensions of play: motor, object, symbolic, and social.

MOTOR & OBJECT PLAY

Much play is rooted in motor play, which includes all physical and manipulative play such as exploratory play - exploring one's body, another person's body, or objects in the environment. Motor play also includes locomotor play,

which is the use of large muscles to move around. Physical growth can be seen in changes in body size and muscle-fat makeup. At twelve months most infants are 50% taller than they were at birth. At two years of age, typical infants have increased their height by 75% of their birth height. By five months, birth weight has doubled to about fifteen pounds, at one year it has tripled to twenty-two pounds, and at two years the infant's weight has quadrupled to about thirty pounds.
The rise in body fat peaks at around nine months to help the infant maintain a constant body temperature (Fomon & Nelson, 2002). In the second year, most toddlers slim down, but muscle mass still increases very slowly during infancy and won't peak until adolescence (Fomon & Nelson, 2002).

As babies are not very muscular, their strength and physical coordination are limited. Motor skills allow babies to master their bodies and the environment in new ways and are divided into two different kinds of motor development. Gross motor development refers to infants' ability to move around in their environment through crawling, standing, and walking. Fine motor development refers to smaller movements that give infants the ability to explore details in their environment and includes the ability to reach and grasp. Table 2-1 shows the average age infants and toddlers acquire basic motor skills.

Motor abilities of newborns include the ability to move body parts in an uncoordinated way (waving arms or turning the head) and involuntary and fine coordinated reflexes (Laura E Berk et al., 2006). In the first year of life, infants develop hand skills to grasp and manipulate objects. This basic form of motor play helps babies acquire understandings of objects, actions, cause-and-effect relationships, and three-dimensional space. Reaching plays a large role in infant cognitive development. By grasping things, turning them over, and seeing what happens when they are dropped, infants learn about the sights, sounds, and feel of objects. Reaching and grasping appear purposeful at about three to four months in the presence of a nearby toy and improve in accuracy during this period (Bhat, Heathcock, & Galloway, 2005). By five to six months, reaching improves as depth perception advances and as infants gain greater control of body posture and arm and hand movements. This leads to increased abilities in grasping as the newborn's grasp reflex is replaced by the ulnar grasp, a basic motion in which the

MOTOR DEVELOPMENT IN THE FIRST TWO YEARS

Holds head erect and steady	6 weeks
Lifts self by arms	2 months
Rolls from side to back	2 months
Grasps cube	3 months and 3 weeks
Rolls from back to side	4 1/2 months
Sits alone	7 months
Crawls	7 months
Pulls to stand	8 months
Plays pat-a-cake	9 months and three weeks
Stands alone	11 months
Walks alone	11 months and 3 weeks
Scribbles vigorously	14 months
Walks up stairs	16 months
Jumps in place	23 months and 2 weeks
Walks on tiptoe	25 months

Table 2-1: Narrowed set of performance requirements based on researcher feedback (Bayley, 2005).

infant’s fingers close against the palm. This grasp then develops into the pincer grasp, which utilizes the thumb and index finger for more coordinated object manipulation.

Babes develop quickly to gain control over their bodies, becoming upright, mobile, and able to explore their surroundings in just a matter of months. One of the major tasks in gross motor development is locomotion, the ability to move from one place to another. Infants progress gradually from rolling (around two months) to creeping on their stomachs and dragging their legs behind them (six to nine months) to actual crawling (seven to twelve months). While infants are learning these temporary means of locomotion, they are gradually supporting increasing amounts of weight while in a standing position. In the second half-year of life, babies begin pulling themselves up on furniture and other stationary objects. Around the ages of twenty-eight to fifty-four weeks, toddlers begin navigating a room in an upright position by holding on to the furniture to keep their balance. First steps alone typically occur between the ages of thirty-six and sixty-four weeks and walking becomes commonplace between twelve to eighteen months. Toddlers practice walking six or more hours a day and could hypothetically travel across about twenty-nine football fields (Adolph, Vereijken, & Shrout, 2003). As movements are practiced and repeated constantly, they promote new synaptic connections in the brain responsible for motor pathways.

Research has indicated that the playful movements of young infants can contribute to fundamental motor abilities. For example, children as young as six months adapt their reaching and grasping to both the characteristics of particular objects they are playing with and the surfaces on which these objects lie (Bourgeois, Khawar, Neal, & Lockman, 2005; de Campos, Rocha, & Savelsbergh, 2010). By ten months, infants form preferences for certain objects and manipulate these in more complex ways than less-preferred play materials (Schneider, 2009). These playful manipulations of objects provide the basis for object control skills, such as throwing, in the preschool years (Bourgeois et al., 2005). Other play position studies have shown that devices commonly found in Western homes, such as walkers, infant seats, high chairs, and stationary play seats with attached toys can inhibit play movements of both arms and legs (Pin, Eldridge, & Galea, 2007). Children who spend large amounts of time in such equipment show delays in motor development (Garrett, McElroy, & Staines, 2002).

In toddlerhood, there is rapid physical and manipulative play development involving fine motor skills with objects and use of large muscles for mobility. Toddlers are usually very active physically. By the age of two years, children have begun to develop a variety of gross motor skills. They can run fairly well and negotiate stairs holding on to a banister with one hand and putting both feet on each step before going on to the next one. Most infants this age climb (some very actively) and have a rudimentary ability to kick and throw a ball. By the age of three, children walk with good posture and without watching their feet. They can also walk backwards and run with enough control for sudden stops or changes of direction. They can hop, stand on one foot, and negotiate the rungs of a jungle gym. They can walk up stairs alternating feet but usually still walk down putting both feet on each step. Toddlers use these new skills for goal-oriented activities and play. As children enter toddlerhood at around 18 months of age—they acquire play abilities that reflect and promote their intellectual development. Their play progresses from simple motor actions to more complex and symbolic behaviors that reflect their growing understanding of the world. For example, they engage in more functional play in which they carry out imitative acts with toys, such as pushing a toy truck while making engine noises or striking a ball with a bat (Laplante, Zelazo, Brunet, & King, 2007). Such play is considered intellectually advanced since it requires children to reflect on the common uses of objects and actions they have observed others perform with them. The development of large muscles and the increasing dexterity of small muscles allows for more sophisticated types of physical and object play.

There is considerable overlap between motor and object play throughout early childhood development. Newborn infants have reflexes and sensory capacities but do not know how to play with objects. They learn how to begin to play with objects as a result of repeated experiences. For instance, a baby might repeatedly drop a rock, varying the height each time and then do the same type of dropping with a stick until the activity becomes less about repetitive exploring and more about play. In this way, object play develops from simple and repetitive motor and functional play routines to elaborate constructive play combinations. Object play refers to using objects in play, which encompasses object manipulation, exploratory play, and constructive play (e.g., block play). Motivation for engaging in object play follows the theory of arousal modulation, which suggests that novelty, complexity, and manipulability motivate a child. Although object play can be complex to analyze, children follow the consistent trend in that, with age, object play becomes more systematic, orderly, and planned (Power, 1999). Functional play is the major type of play from birth to age two. Object manipulation advances from oral (mouthing) or large motor handling (banging) of a single object to the coordinated use of both hands and eyes with multiple objects. Manipulative object play becomes more focused and sustained as infants gain the ability to use objects in multiple ways (Power, 1999).

SYMBOLIC PLAY

Symbolic play develops from motor and object play to include pretend actions, use of objects, role enacting, and (at older ages) themes. At around twelve months, infants exhibit basic pretend play involving only themselves (Fenson, Kagan, Kearsley, & Zelazo, 1976). These pretend play behaviors represent everyday experiences, such as pretending to sleep or talking on the phone. Infants and toddlers soon become increasingly able to pretend with/ a variety of substitute objects (Johnson, Christie, & Wardle, 2005). As infants age, their use of symbolic and pretend play grows from earliest imitations of self and others toward more coherent and orderly symbolic play and planning.

SOCIAL PLAY

As a child grows older, there is an increase in interactive play with a variety of social skills unfolding. All play unfolds in a social context, and social play has origins in the first infant games that involve a partner who compensates for the child's limitations (e.g., peek-a-boo). Objects inspire social play as they encourage infants and toddlers to play together (Stambak & Verba, 1986). This occurs with joint-play in a specific play area. Children in close proximity co-construct their play area, in which children share toys and engage in collective pretending. Therefore, in addition to observing and catering towards play development for individuals, play environments should also serve groups of children.

GENERAL OVERVIEW OF PLAY TYPES

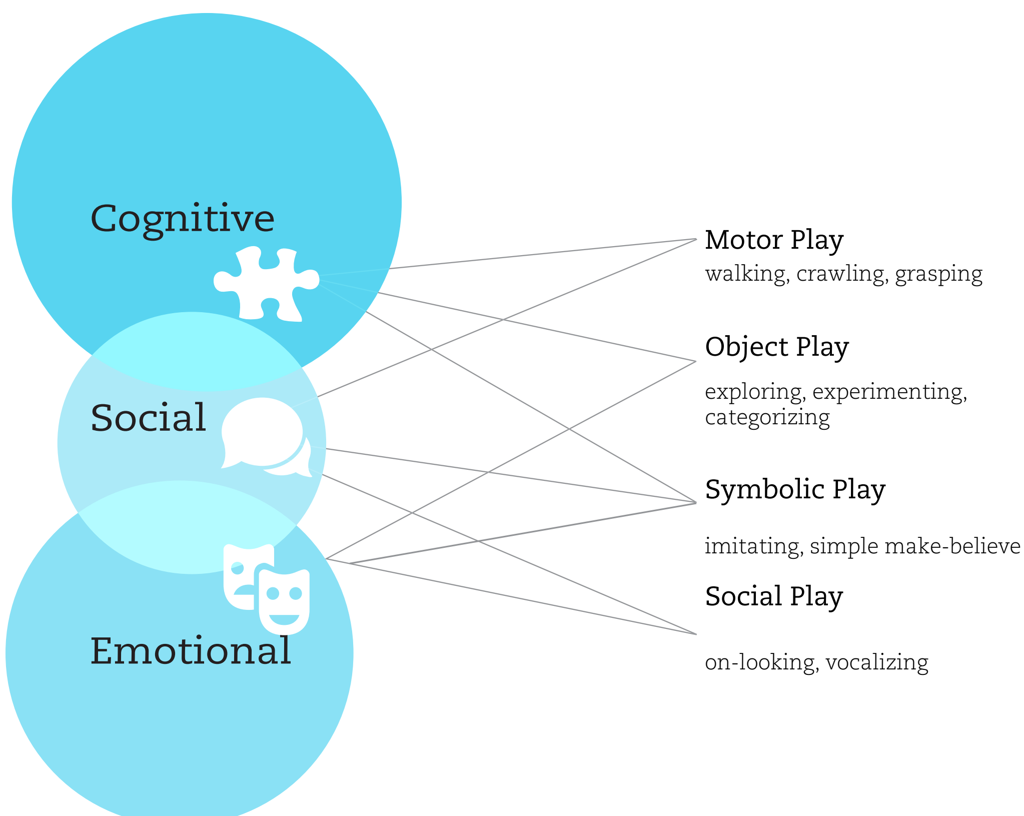


Figure 2-2: Play Types

Section Two

Bioecological & Sociocultural Development

Early child development in a social and cultural context.

“It takes a whole village to raise a child”

– Igbo and Yoruba (Nigeria) Proverb

Bioecological Views of Early Childhood Development & Play

In order to look into the contextual aspects of child development, the Bronfenbrenner (1979) model of ecological development provides a framework to analyze the societal and physical environment in which children grow. This theory essentially contends that development is a combination of the person and the environment. Human development takes place in the microsystem through proximal processes, the interactions between a person and his or her biological systems, objects, symbols, other persons, the environment, and time (Bronfenbrenner, 1979). In this model, development is a function of a process, characteristics of the developing person, environmental context, and time (Bronfenbrenner & Evans, 2000). Bronfenbrenner’s bioecological model looks at the individual’s interactions with multiple “systems” at work in environments that range from immediate home environments to the environments of culture and society.

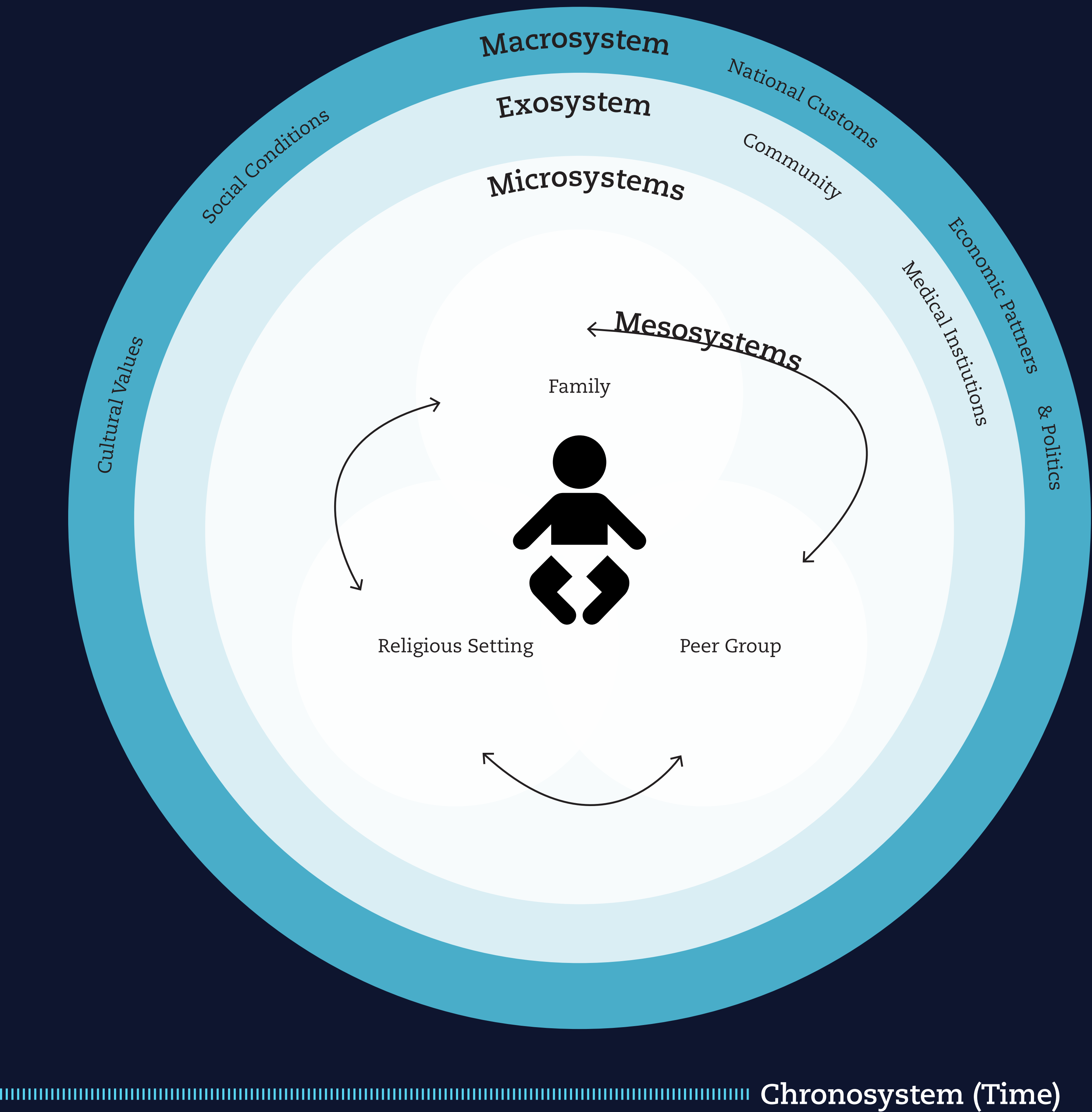


Figure 2-3: Bronfenbrenner's Bioecological Model of Development (1979)

As presented in his Ecology of Human Development (1979), Bronfenbrenner explains that a child's world consists of five systems of interaction: microsystems, mesosystems, exosystems, macrosystems, and the chronosystem (Figure 2-3). Every child's ecological system is unique because every child has a different set of variables that affects his or her life and development. By considering these variables, outsiders can begin to understand the child's values, beliefs, achievements, and behaviors. Microsystems are all the settings that directly influence a child because the child directly interacts with the systems. These could include school, the family, or a peer group. The mesosystems are relationships between microsystems, such as the relations between home and school or school and workplace. Exosystems are systems that affect the developing child but not in a direct way. Some examples of exosystems include parents' workplaces, family social networks, and neighborhood-community contexts. The macrosystem is the overarching culture and belief systems to which child belongs and every child lives in a span of time called the chronosystem (Bronfenbrenner & Ceci, 1994). Each system depends on the context of the person's life and offers an ever growing diversity of options and sources of growth.

While there are many systems at work in an infant's life in rural Zimbabwe, this project focuses on the homestead microsystem that most immediately and directly impacts the child's development with regards to safe play and E.coli consumption (Figure 2-4). Life revolves around the kitchen area. Husbands do not contribute to housework but the husband's extended family is typically present in daily life. The homestead revolves around mealtimes, bathing, sleeping, and family interactions (Figure 2-5). Outside of the immediate homestead compound, church occurs anywhere from one to three times per week depending on the community. At least one day is reserved for church and no work occurs in the fields. Church is not a formal, physical structure but rather a community gathering. A protective playspace should therefore be integrated into the local homestead lifestyle.

Play in a supportive environment can stimulate optimal brain development to help children reach their full potential (J. E. Johnson et al., 2005). Recent brain research has shown that optimal brain development occurs when the child interacts with a responsive environment, while stress, boredom, constant chaos, and lack of appropriate stimulation from an unresponsive environment can negatively affect brain development (Shore, 1997). In addition to emotional warmth from parents while interacting with their children, a healthy home environment includes provision of a stimulating environment for learning experiences and attention to the safety and cleanliness of play areas. A child who is engaged in a variety of play activities interacts with the environment around him or her. In this way, play keeps the child's mind actively involved in the environment to produce positive developmental effects.

The quality of the home environment is a salient mechanism through which income may alter child development. Several studies of young children have found that quality of the home learning environment accounts for a substantial share of the effect of poverty on children's achievement and behavioral outcomes (Leventhal & Brooks-Gunn, 2003). Poor children are likely to be raised in less emotionally, cognitively, and physically enriching environments than children from more affluent families. Accumulated research evidence has shown that infants who were raised in families that did not provide rich language and play experiences dropped drastically in IQ by three years of age compared to those raised in developmentally more stimulating environments (Golden, Birns, Bridger, & Moss, 1971).

THE HOMESTEAD MICROSYSTEM

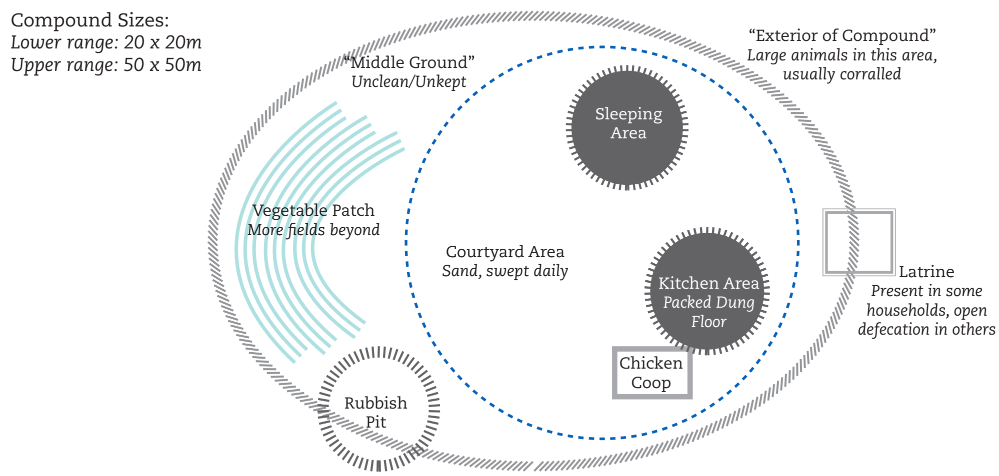
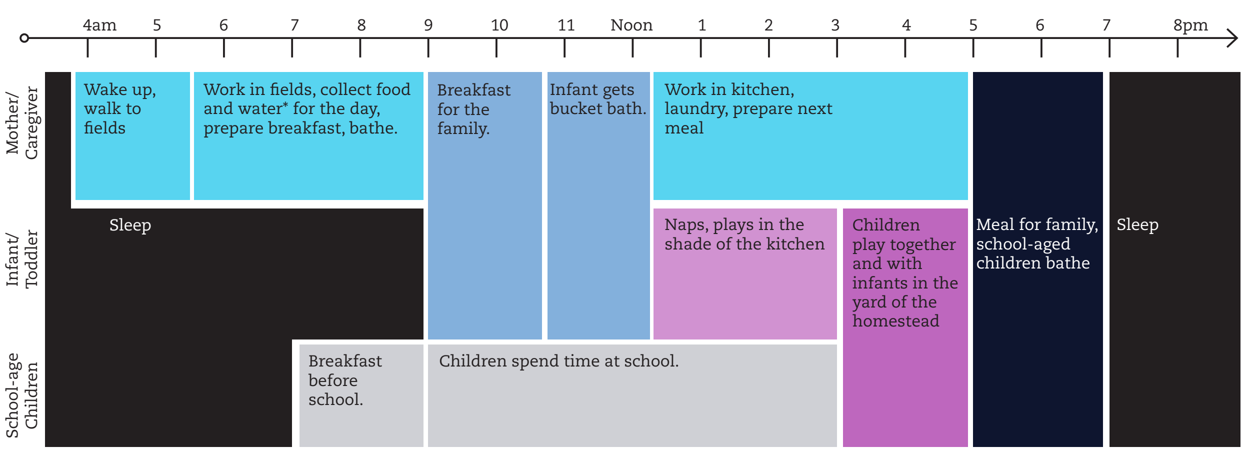


Figure 2-4: Typical homestead structure in rural Zimbabwe

A DAY IN THE LIFE: A RURAL ZIMBABWEAN HOMESTEAD



*Water and fields are often a few km away in a pond, well, or bore hole.

Figure 2-5: Prototypical day in the life for a rural Zimbabwean family.


OUTDOOR

Sociocultural Views of Early Childhood Development & Play

In recognizing that play behaviors are activities in social contexts shaped by economic, social, and political factors, there is also a need to explore the cultural and communal aspects of play touched upon in the bioecological model. The physical environment is important, but it's not all-important. The social environment is also important for learning, health, stress, and sociability (Rogoff, 2003). Individual characteristics also lead occupants to respond differently to the same setting. The sociocultural theory of child development begins to address this additional complexity; expanding on the "culture" macrosystem of Bronfenbrenner's bioecological model (Vygotsky, 1978). This theory sees play as "cultural activity and interpretation that require interdisciplinary thinking and research in order to grasp the meaning of children's play in a cultural context" (Rogoff et al., 1993). Vygotsky's sociocultural theory suggests that children live in social and cultural contexts that affect the way their cognitive development is structured (Bodrova & Leong, 2007; Rogoff, 2003). Therefore, complex mental activities such as categorization and problem solving are rooted in social interactions with inherent cultural meaning. The concept of proximal development explains how this happens. The zone of proximal development refers to a group of tasks that the developing child can not yet do alone but can do with the help of more skilled partners. Eventually the child can do the tasks by himself or herself, but the other skilled partner has scaffolded the child's learning. Adults adjust the

Figure 2-6: (Opposite) Children sit outside.

environment and their communication in ways that promote learning adapted to their cultural circumstances. By taking this perspective on child's development, the designer also attempts to overcome the dualistic relationship of the person and the environment by blending them together, with culture as the meeting point. Sociocultural perspectives can also help to inform the implementation of culturally congruent early child development and WASH interventions. This approach begins to articulate a culturally sensitive theory of play that seeks to explain how universal and cultural variables of play interact with specific communities to create distinctive developmental pathways (Haight & Black, 2001).

Anthropological studies reveal striking cultural variations in play (Schwartzman, 1980). Distinctive developmental pathways are evident in the way that children of different cultures play. A sociocultural approach to the study of play is important because it can help designers and researchers determine what interventions and ideas can be transported from one cultural community setting to another (Shweder, 1991). Children at play are using and developing a wealth of information, skills, and dispositions that have important roles in becoming competent members in their own cultural communities. Society provides children with opportunities to represent culturally meaningful activities in play. Make-believe, like other complex mental activities, is first learned under the guidance of experts - adults or siblings - who model the prevalent ideas and activities of the culture in which the child is raised (Laura E Berk et al., 2006). Vygotsky emphasized that "natural" lines of development (universal) must be studied along with “cultural” lines of development (culturally specific) (1978).

Cultures can be categorized in a rudimentary way as either “high” context or “low” context (Hall, 1969). American culture is considered a predominately low-context culture. This means that the society as a whole values the individual over the group and values individual independence and success as the highest possible virtue. Child rearing and education are then focused on “teaching their citizens to assert themselves, take initiative, explore, and achieve” (Kaiser & Rasminsky, 2003). Rural Zimbabwean culture, in contrast, is predominately high-context. In high-context cultures, individuals are interdependent on each other and identify themselves through their membership within a group such as a family, community, or ethnic group. The individual’s worth and status, therefore, are based on their contribution and functioning within the group. Individual achievement that conflicts with the group values is viewed as selfish.

These cultural differences have a direct impact on how children play and, by extension, how play pens might be either beneficial or harmful to such play. In low-context cultures, play is focused on developing individual skill and competencies, individuality, leadership, self-expression, and continually pushing children toward independence. The imaginative and transformative games that are common in western low-context culture are often used in solitary situations and stress detachment from the mundane world to dream up things that are not present (Sutton-Smith, 1972). American play pens highlight this propensity towards individuality, as they are constructed to contain one child and, when toys and games are embedded within the structure, focus on individual learning and games rather than games that inherently invite others to participate. On the other hand, in high-context cultures, play focuses on cooperation, sharing, group loyalty, and learning to put aside individual needs and wants for the collective good. Group games take a high precedence (Kaiser & Rasminsky, 2003). An oral style of imagination is a play style that places the focus between the central performer and the group and is often found in low-context cultures (Sutton-Smith, 1972). American play yards do not fit these concepts of play and societal structure precisely because they do not afford for multiple children of varying ages to interact with the child inside of the playpen and do not include group or social toys within them. If designers and water, sanitation, and hygiene experts are to adequately address the needs of both the children and the play concepts of the community's parents, such play styles must be identified and catered to in a responsible and respectable way.

While there are some generally universal dimensions to play that include the use of objects and the predominantly social nature of pretend play, cultural variables introduced by children's parents impact play in ways that cannot be ignored by design interventions in play spaces (Haight, Wang, Han-tih Fung, Williams, & Mintz, 1999). Design interventions in play space should be based on the consideration of culturally variable dimensions including the participation of specific play partners, the extent of child initiations of social pretend play with caregivers, the various functions of social pretend play in interaction, and specific themes. Brain research has shown that optimal brain development occurs when the child interacts with a responsive environment, while stress, boredom, constant chaos, and lack of appropriate stimulation from an unresponsive environment can negatively affect brain development (Shore, 1997).

The physical and social play environment is shaped by the culture and concepts of the parents. Thus, design interventions must respond to cultural constructs of social systems in order to provide an appropriately stimulating play environment.

Section Three

Design for Children

Case Studies

A case study is a descriptive analysis of another design in a similar field or expertise. Case studies can be used to explore underlying principles, values, or challenges that similar design problems face. The design case study subjects in this project were selected for further investigation with the criteria that they relate to children, play, spatial design, or culture.

Leadership Academy for Girls

The Oprah Winfrey Leadership Academy for Girls in South Africa is a female boarding school founded in 2007 with the intention of providing educational and leadership opportunities for girls from impoverished backgrounds. Designed by Mashaban Rose Architects, the architecture reflects the myriad of cultures evident in the diverse student population. To fully appreciate the cultural heritage of the incoming class of students, the designers and consultants went into communities, visited schools, and talked to peers. They then used this information to then inform the design of the site plan, architecture, and details throughout the school. Seating options for outdoor classrooms were created to take advantage of the climate and the beauty of the South African landscape and show mindfulness towards the context (OWP/P Cannon Design, VS Furniture, & Design, 2010).

Observation showed that South African girls often sit in circles to talk, sing, or dance. To reflect this, the campus buildings wrap around to make outdoor spaces that encourage comfortable circular gatherings. Some visual ethnography revealed local building techniques that were translated into modern architecture. The designers used scratched plaster, a common decorative technique in rural mud houses and floors, throughout the school as an accent. The designers also sought to use each culture's associated beadwork, so columns with the beadwork translated into a mosaic were placed in a prominent place on the campus. Use of rich cultural traditions offer design opportunities and embracing them is a mark of respect. Additionally, observational and ethnographic research allows for respectful interpretation of local building, craft, and art styles.

Play Mats for the Visually Impaired

Reach&Match is a Braille learning toy designed by Mandy Shuk-Man Lau for visually impaired children. The modular set of reversible play mats uses sound and texture to engage children. Affording various combinations, the mats encourage children to explore their physical environment. Intended to increase early childhood exposure to Braille literacy, the sensory play toy provides an engaging way to practice mobility and identify tactile patterns. The project researched Braille literacy, early childhood education for visually impaired children, and observation from children with multi-disabilities. "Reach&Match" provides a case study for the deep consideration of every detail with regards to early childhood play.

Design development was conducted through a collaboration with Vision Australia, allowing Braille teachers to directly inform the design exploration and modifications. The design considers a host of different stakeholders to include children with visual impairments, early childcare professionals, parents, and manufacturers. Group play is encouraged for all children as "Reach&Match" addresses universal goals of sensory and motor development. In this way, group play also begins to break down barriers between sighted and visually impaired children. Furthermore, the portable nature of the design allows Braille teachers to bring the toy to different schools for more children to enjoy. Material considerations favored a design that could be easily mass produced by existing technologies and skills. To address the users of developing countries, a fabric version of

Figure 2-7: Foam Prototype of Reach&Match. Photo Credit: Mandy Shuk-Man Lau

Figure 2-8: Fabric Reach&Match. Photo Credit: Mandy Shuk-Man Lau


a/1
b/2
d/4
e/5
g/7

the design was developed using accessible raw fabric materials and basic sewing skills. The project is a naturally tactile toy that introduces children to Braille and understanding objects in their environment. Children naturally like to reach, touch, and feel things, making this project notable for designing for visually impaired children's needs (Shuk-Man Lau, 2012).

CASE STUDY INSIGHTS

>> The design uses and focuses on research for early childhood social interaction and sensory development.

>> Lau cites collaboration with experts and user-testing as key drivers for design ideation and refinement

>> Reach&Match is an inclusive design for multiple groups of children and can be translated into developing contexts.

Figure 2-9 (Opposite): Reach&Match Detail. Photo Credit: Mandy Shuk-Man Lau.

Weplay Octagon Creative Block Set

Weplay aims to create educational products that promote children's communication and motor skills and stimulates their creativity while they learn. The Octagon Creative Block Set is described as a product for "holistic child development" that enriches play activities and creative thinking. The set of Octagon Building Blocks comes in vibrant colors and affords children using them to fence sandboxes, dramatic play, or simple structure building. Additionally, the blocks can be used to enhance classrooms or provide seating for toddlers. The intuitive assembly encourages creativity and imagination (WePlay, 2013).

CASE STUDY INSIGHTS

>> The scale, color, and tactile nature of the blocks allows for various kinds of dramatic, motor, and block play.

>> The octagonal shape of the blocks creates a modular unit, and care has been given to how the blocks stack and grow.

>> A focus on universal design for multiple age ranges of children allows for mixed-age peer groups to interact.

Figure 2-10 (Opposite): Children playing with creative block set. Photo Credit: Weplay.


Non-slip feet feature

Section Four

Design Guidelines

Introduction

Design guidelines identify specific objectives that the design should aim to achieve. These guidelines are based on analyses of constraints and goals brought to light by extensive research. Guidelines are unique to each design problem but it is important to note that no comprehensive list will accurately reflect all of the needs identified by users and designers of any project. Guidelines serve as a way to assess if the new environment is a quality one for people, if alterations of the environment would help improve current issues, and if the physical space design can contribute to positive growth for users (Steele, 1973).

In this project, the design guidelines to follow first provide a brief review of the literature that they are drawing from and give an example of a user-space incongruence. Performance requirements distilled from the research then are presented at the end of each guideline. Finally, the guidelines demonstrate a rough example of how the performance requirements might be achieved.

Guideline 01

Provide a nurturing and sensory-rich environment for children’s earliest interactions with the physical world.

Performance Requirements

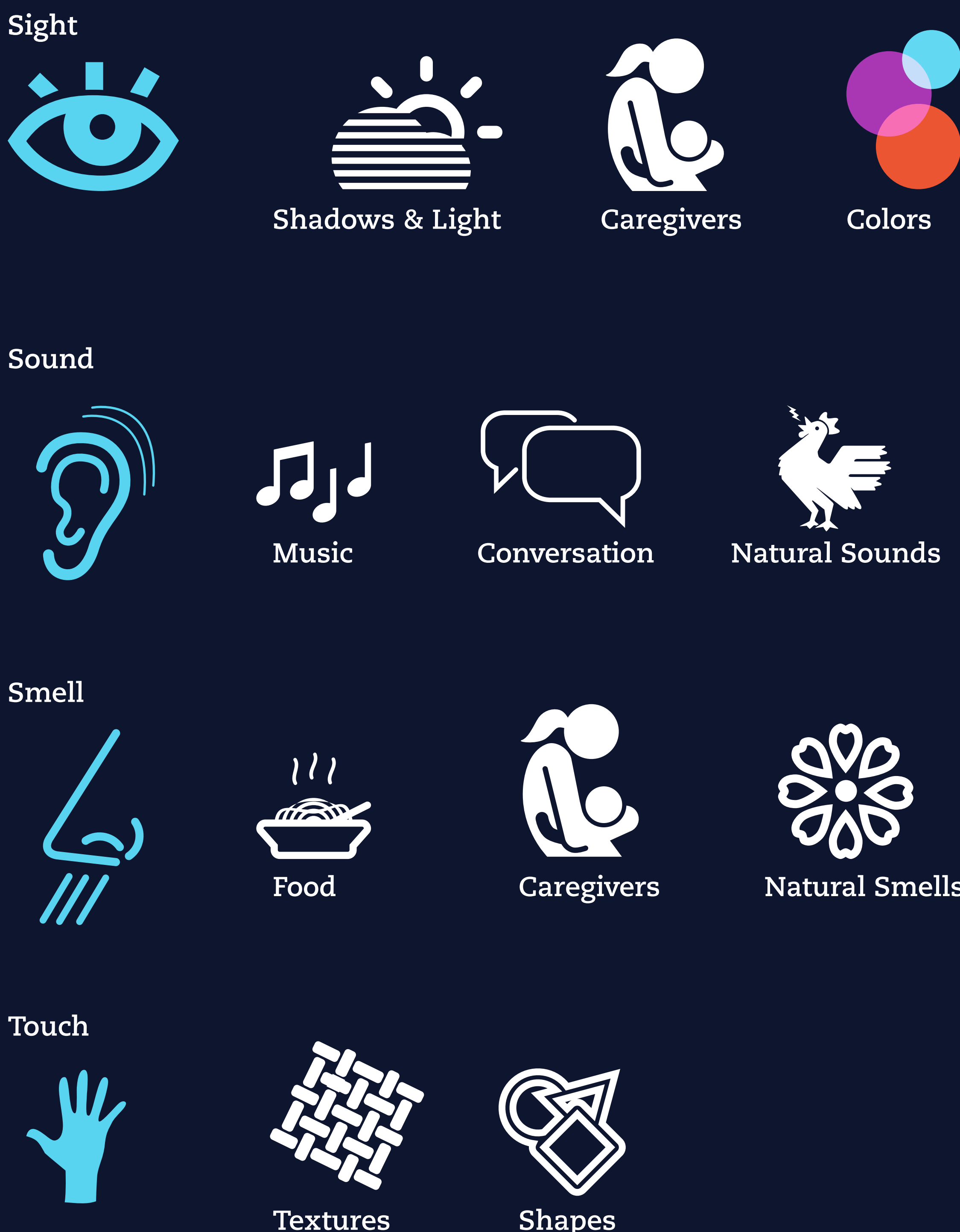
- >> The play space should provide active and socially relevant play, which is required for healthy brain growth
- >> Provide an environment filled with sensory experiences and access to smells, sounds, colors, plants, and moving creatures, light and shadows, and varied tactile experiences.

Stimulating Play

Stimulating play affords infants the opportunity to master skills in memory, information processing, and other cognitive abilities necessary for learning (Piek, Dawson, Smith, & Gasson, 2008). Studies have shown a direct link between play in young children and memory, school adjustment, oral language development, and improved social skills (Bodrova & Leong, 2003). Thus, quality play in early childhood is a prelude to positive functioning later on in development (J. E. Johnson et al., 2005). Play interaction with the environment is therefore a critical area of design research and innovation to support early childhood development (Jenvey & Jenvey, 2002). Skin is the largest organ of the body and touch is the most critical sense for children under three (Montagu, 1971). Infants experience their environment through sensory perception and exploration, which in turn contributes to the learning and development of important cognitive concepts (J. E. Johnson et al., 2005). Visually perceptible information contributes to the development of infants' cognitive understanding of motion, depth, and event sequencing (Lerner, Jacobs, & Wertlieb, 2005).

Cognitive and motor development take place through manual activities and tactile exploration within the environment. The young brain's rapid development depends on ordinary experiences such as opportunities to see and touch objects, hear language and other sounds, and move about and explore. These experiences occur early and naturally as caregivers offer babies age-appropriate play materials and engage them in enjoyable daily routines (shared meals, games, bathing, singing) (Huttenlocher et al., 2002). The environment provides rich sources of information about shape, texture, consistency, object properties, and the development of object representations and auditory signals from environmental sounds contribute to word learning and joint attention (Vygotsky, 1978). The unique contribution of sensory stimuli from each of these sensory modalities maximizes perceptual learning and cognitive development and occurs specifically through infants' play and exploration of their microsystem environment. Children learn about their world through exploration and consolidate that information in their play (J. E. Johnson et al., 2005). Thus, interaction with the environment through play supports the total development – social, cognitive, affective, emotional, and physical – of all children.

Designing for the Senses



Guideline 02

Encourage children to move and to delight in practicing new physical skills.

Performance Requirements

- Infants need broad horizontal surfaces with minimal boundaries.
- Toddlers need opportunities to roam over a varied landscape of subtle three to six inch changes in level that satisfy their desire to balance and walk.
- Minimum available free play space for infants at 50 square feet/child
- Minimum available free play space for toddlers: 75 square feet/child (recommended 90-100 square feet/child)
- Provide an engaging space that encourages motor exploration.

Motor Play & Development

Once infants can crawl and pull themselves up, moving becomes a major focus of their day. The physical environment profoundly influences motor skills. Research has shown that infants with stairs in their home learn to crawl up stairs at an earlier age (Berger, Theuring, & Adolph, 2006). Slight changes in level can challenge the crawling, climbing, and balancing skills of toddling children. Babies' visual surroundings are also influential. Institutionalized infants given a moderate amount of visual stimulation (such as simple designs and later a mobile) reached for objects six weeks earlier than infants given nothing to look at (White & Held, 1966). In cultures where mothers carry their infants on their hips or in slings for most of the day, babies have many opportunities to explore with their hands. In the !Kung of Botswana, infants explore their mothers' beaded necklaces (Konner, 1977). Babies of Mali and Uganda spend much of their day held in sitting or standing positions, which facilitates reaching. These groups of infants often they develop manual skills earlier than western infants (Karasik, Adolph, Tamis-LeMonda, & Bornstein, 2010). Physical well-being, health and motor skill development in a child are critical to future development. Play spaces should encourage activities that develop strong motor skills so that children can explore their environments while they gain confidence in their physical abilities.

Guideline 03

Maximize children's physical and emotional contact with adults and caregivers.

Performance Requirements

>> Cultural play styles must be identified and catered to in a sensitive and acceptable way.

>> Create a safe play space that is also inviting to older siblings and multiple children in community-based homesteads.

>> The visual and physical design of the space should reflect the homestead and the cultural values expressed within the community.

Social Connections

Normal development requires a balance between time spent with the infant's caregiver and time spent freely exploring the environment (Lozoff et al., 1998).Child play happens in a cultural context, and while there are universal developmental schedules, play unfolds itself around culturally influenced behaviors (J. E. Johnson et al., 2005). Therefore, play spaces must be responsive to the dominant adult concepts of child-rearing and social interaction (Haight et al., 1999). Culturally variable dimensions include the participation of specific play partners, the extent of child initiations of social pretend play with caregivers, the various functions of social pretend play in interaction, and specific themes (J. E. Johnson et al., 2005). Researchers introduced American playpens in a small pilot study in Zimbabwe but elicited some negative reactions from the community for a number of reasons, based primarily on cultural concepts of play (Zvitambo, unpublished). For instance, mothers commented that their "child will not have room to experiment," and "people need to understand why the child is being kept in a play pen," in reference to the general cultural practice of not using any child containment. In the focus group, one mother was adamant about not using a play pen, expressing concern about her child hurting himself. She said the American play pens were "too small… my baby needs all the yard to explore."

Cultural differences also have a direct impact on how playpens might be either beneficial or harmful to specific cultural play forms. American playpens highlight a Western propensity towards individuality, as they are constructed to contain one child and, when toys/games are embedded within the structure, focus on individual learning rather than games that inherently invite others to participate. If play space designers and WASH experts need to adequately address the needs of both the children and the play concepts of the parents.

Children's social play in traditional societies prior to age-graded schooling is most often age mixed (Gray, 2011). In many societies, children care for their younger siblings, which often means including them in their play groups. With this in mind, creating a safe play space that is also inviting to older siblings and multiple children will protect the important social interaction between infants and siblings.

Guideline 04

Facilitate caregiver tasks and encourage use of the protective play space.

Performance Requirements

- >> Playspace accommodates variable terrains
- >> Easy to maintain and keep clean
- >> Playspace is easy to understand and intuitive to put together
- >> Playspace is easy to move, shift, and store
- >> Playspace is resistant to everyday wear and tear.
- >> Design prohibits child-chicken interactions.
- >> Design follows applicable safety guidelines.
- >> Design reflects current ECD literature available to rural mothers.

Encourage Use

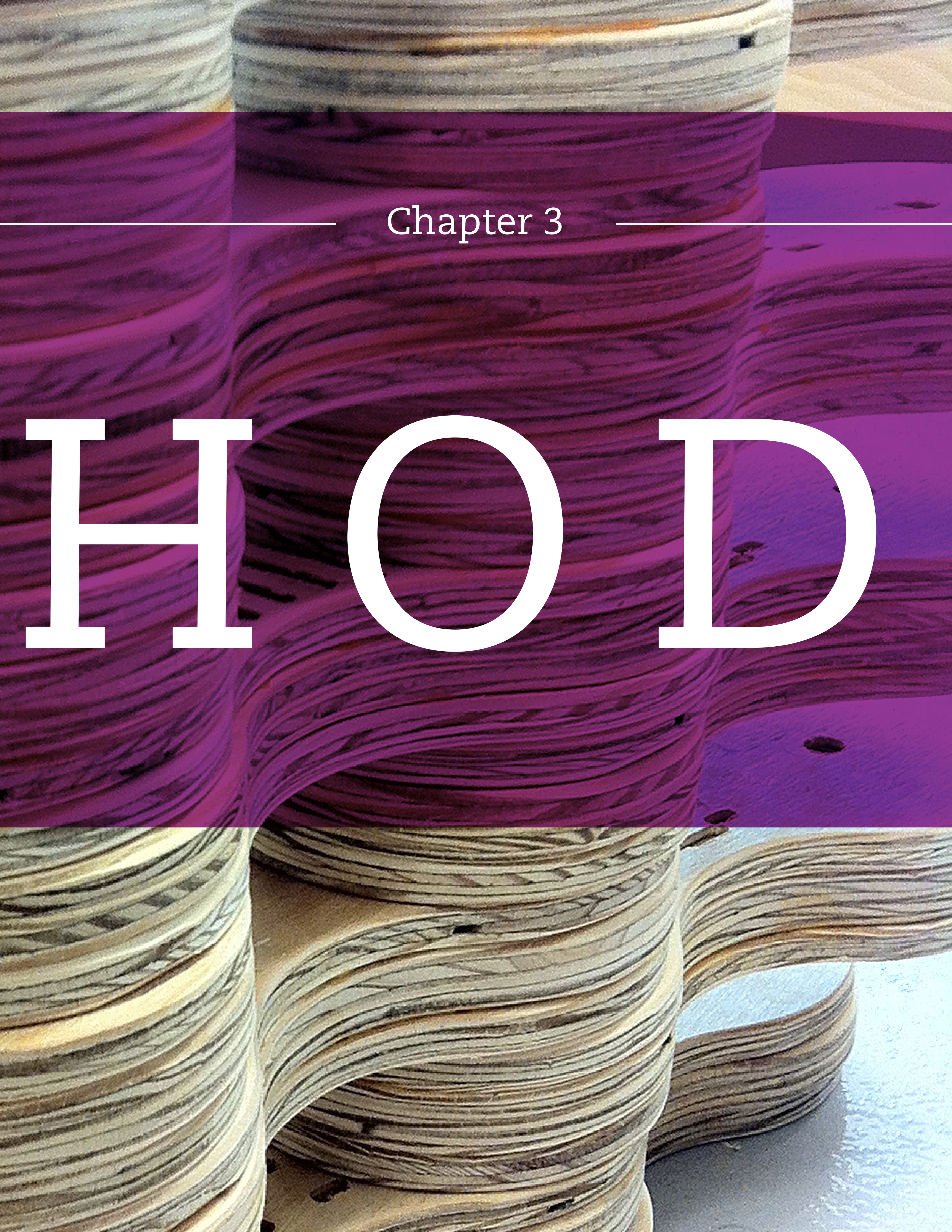
When interviewing mothers on using mats and play-yards, a few items of concern arose. The first was that the space must be safe. Safety of protective play space design is imperative. International standards for full size baby cribs can provide a basis for safety (Chan-Yip & Gray-Donald, 1987). Safe designs will follow applicable safety specifications, performance requirements, structural integrity, and design requirements to prevent entanglement on elements such as corner post extensions. Safety also includes the long-term ability of the space to accommodate various terrain types, weather seasons, and general pests (e.g. termites) that might lessen the stability or safety of the playspace.

The second item of concern for mothers was the difficulty of keeping the baby in one place away from contaminated ground. Contamination of the domestic environment with animal and human feces in poor households is ubiquitous. Human and animal feet carry feces deposited in the open, bringing diverse microbes and pathogens into the domestic environment and the immediate vicinity of infants and young children. Therefore, the design should keep infants separated from chickens by providing a direct means of separation that is intuitive for caregivers to use and assemble.

Mothers were very interested in their child's brain development. They were therefore responsive to play-yards that matched early childhood development literature by providing colors, textures, and shapes in a play environment (see Design Guideline 1). These benefits of the play environment should be communicated to mothers.

Finally, the concern of neglect was an issue for both mothers and researchers when discussing the concept of play-yards. While there is no documented evidence specific to play-yard neglect, neglect can occur in response to poverty, stress, or caregiver depression. The design of the protective play space should encourage social interaction between the infant and family to mitigate potential for isolation.


MET



Chapter 3

HOD

Section One

The Approach

Social Research & Design

> **“Social design is working with people rather than for them; involving people in the planning and management of the spaces around them; educating them to use the environment wisely and creatively to achieve a harmonious balance between the social, physical, and natural environment.”**
>
> *– Robert Sommer (1983)*

The design of objects and spaces ultimately seeks to enrich the quality of life in the home, workplace, or public domain. Social design, that is also evidence-based, creates a concrete way to enrich the quality of people’s lives by studying how settings can best serve human desires and requirements (Sommer, 1972). Social design favors a methodology that is small-scale, human-oriented, low-cost, inclusive, and concerned with meaning and local context.

This ideological framework is important because many spaces have been constructed that didn’t consider the needs of their users. Design must focus on humane place-making (Sime, 1986). In other words, designers must create spaces for real people and real behaviors (Schneekloth & Shibley, 1993). Social research in the design process is the first step in acknowledging the realities of users and uses of a design. In this project, there are a number of goals that research in the design process hopes to accomplish through the generation of design guidelines, noted in the previous section.

First, design guidelines and research help to create a physical setting that matches the needs and activities of its occupants. In this case, the playspace should match the need of protecting children from environments contaminated with E.coli. The playspace also should match the play activities of children as well as the common activities of a homestead in rural Zimbabwe. The design should enhance personal control by affording users the ability to alter the playspace to suit their needs with regards to storage, shape, and size. Ideally, the design will satisfy users on multiple levels. The play environment should meet the developmental and protective needs of both infant occupants and their caregivers. Caregiver satisfaction is especially important because the explicit hope is to create a playspace that promotes behavior-change around infant hygiene and sanitation. There are obvious benefits to evidence-based design: the users receive a more congruent space to support their day-to-day behavior, the designers receive feedback for improvement in the design of the next space, and the public benefits from shared project insights (Gifford, 2007). The design and research methodology described will also be explored in the context of this project and the iterative nature of the evidence-based design process. Iterative design is a methodology based on a cycle of informing, prototyping, testing, analyzing, and refining a design. Intended to improve the quality and functionality of a design, changes and refinements are made based on results of testing the latest design iteration. Viewing design as a spiral process reflects designer's tendencies to backtrack between design solutions, to repeat the same series of activities, and the general movement towards a consolidated design solution (Zeisel, 2006).

The Design Development Spiral

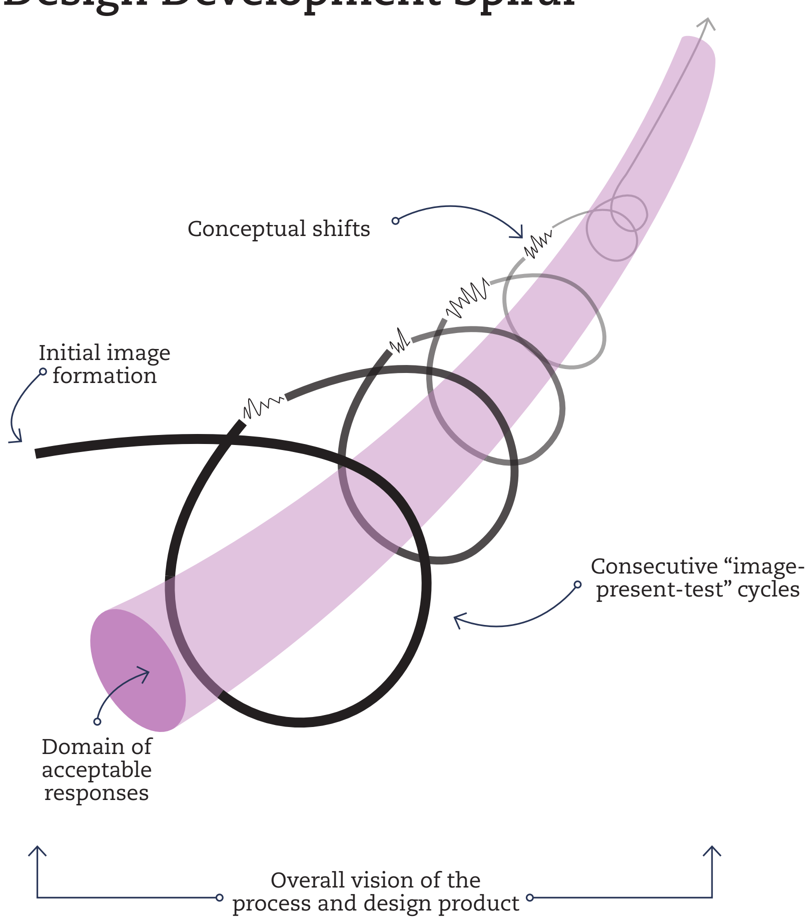


Figure 3-11: Design Development Spiral (Zeisel, 2006).

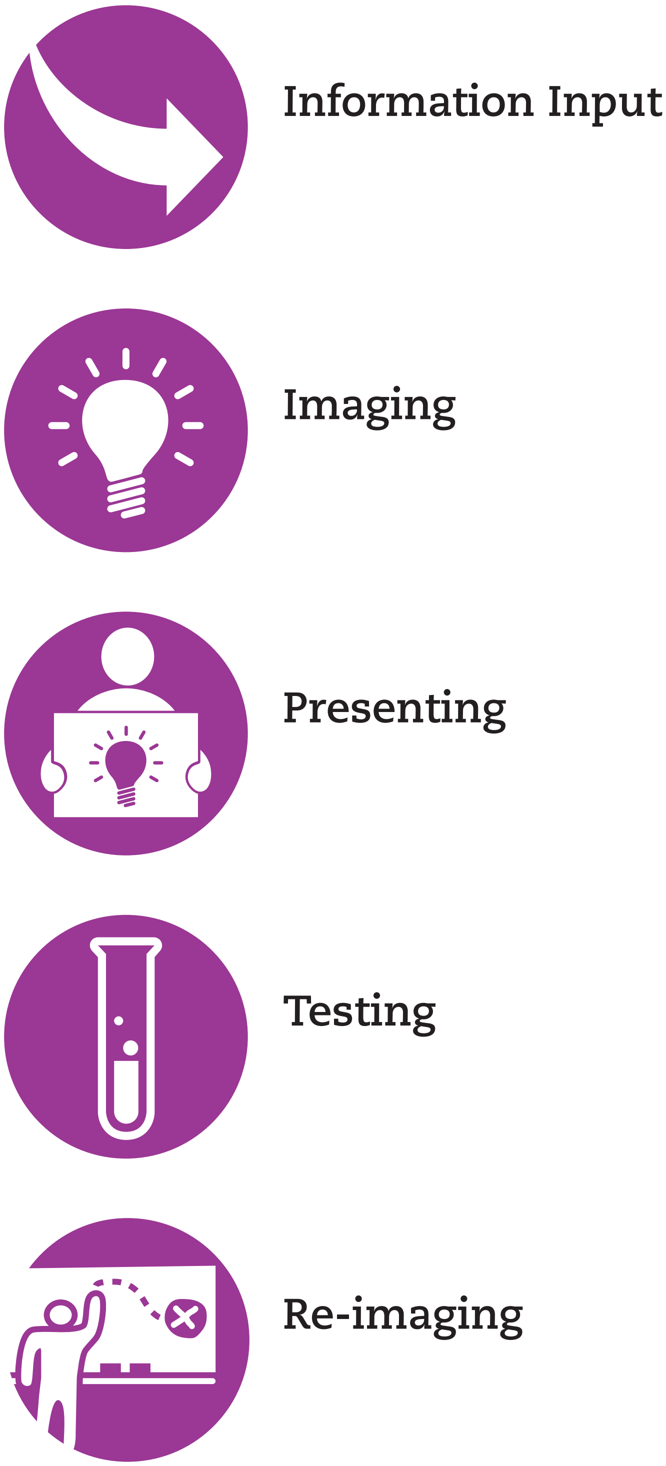


Figure 3-12: Design Process Activities adapted from Zeisel (2006).

Activities of the Design Process

Design is never a one-dimensional activity. Similar to child development, it is a complex activity that can be thought of as several different analytical activities displayed in figure __: information input, imaging, presenting, testing, and re-imaging (Zeisel, 2006). *Information input* lies at the core of the design process and consists of a body of research and design guidelines that help to inform design generation as well as assess design decisions. Korobkin (1976) provides a framework of two different kinds of information that designers use: image information and test information. Image information provides a general understanding of important issues in the design project. While image information can convey a feeling or mood of an environment, it can not be used to evaluate isolated specifics of a design concept (Zeisel, 2006). Test information, on the other hand, is directly related to evaluating a possible design solution. Information input helps to generate the images that the designer will then develop and test.

Imaging is the formation of a general picture of a part of the design (Zeisel, 2006). Images are often visual and provide a larger framework that specific pieces of the design problem fit within. Designers use their images of eventual solutions to define better the design problem they are working on and to guide the search for answers (Foz, 1972). Imaging can be paralleled with researchers' working hypotheses (HIllier, Musgrove, and O'Sullivan, 1972).

Presentation is a tool that designers use to make images visible to

The Design Process Cycle

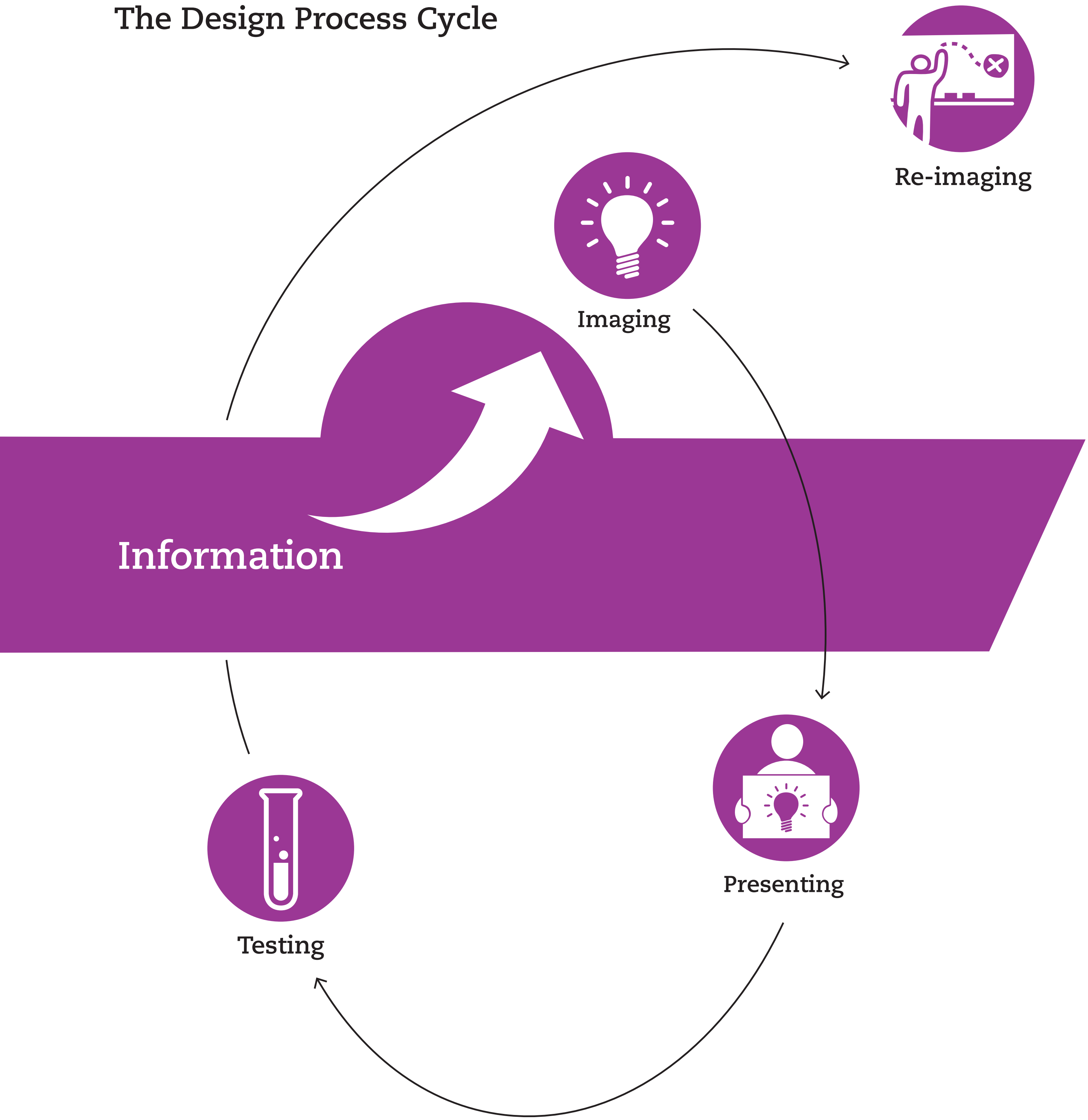


Figure 3-13: Design Process Cycle adapted from Zeisel (2006).

themselves and others. Presenting allows designers to externalize and communicate their ideas so that they can use and develop the ideas further. Presenting can take many forms including sketching, drawing plans, building models and prototypes, and taking photographs. These activities pave the way for evaluation and improvement on possible design solutions. *Testing* refers to the act of comparing presentations with the designer's internal ideas of the design solution, constraints, objectives, consistency, and performance criteria. Testing contributes to design innovation while narrowing the range of design possibilities to the problem at hand. Testing is a feed-back and feed-forward process as it serves as an intermediary between the initial criteria and the final design solution (Zeisel, 2006). Insights gleaned from subsequent tests are then fed into the imaging process again to result in a *re-imaging* of the initial design ideas and information. The cycle repeats itself many times until a solution in the domain of acceptable responses is decided upon (Figure 3-13). Information is continuously gathered, transformed, and reinterpreted as the design is refined. This chapter breaks down the protective playspace's initial design development cycles through the five design activities to provide a robust view into the design process.

Section Two

Iteration One

Informing Design Cycle One

The initial design cycle started with a critical look at the American play-yards introduced to a cohort of rural Zimbabwean caregivers in a series of small pilot studies (Zvitabmo, unpublished). The study began with informal discussions with caregivers about the idea of a safe play area in general, and was then described as a large "box" that confined the child. Mothers reacted negatively to the idea, believing a "baby container" was too cruel, because their baby would be hindered from exploring the world and developing appropriately. After this initial conversation, researchers conducted more formal focus groups with men and women. This time, a safe play area that looked like a mat was introduced to mothers on a card, along with instruction of the importance of protecting the child from soil and feces. Caregivers expressed interest in a physical object for crawling infants, which they called a "playmat."

Caregivers participated afterwards in a series of in-depth interviews with three imported play-yards. The first was a small, travel sized play-yard commonly referred to as a "pack-and-play" (Figure 3-16). Mothers liked the small play-yard for their infant to sleep in, but thought it was too small for older children or everyday use. The second play-yard was a simple gray fence system (Figure 3-18). Both children and mothers were less interested in this as an option for a play-yard due to a lack of colors and space. The third play-yard introduced was colorful and also the most successful in terms of mothers' interest in it for their children (Figure

3-20). Caregivers liked the idea that the play pen could be moved and shared with others. Mothers also liked that it was colorful, included toys, and was plastic and therefore highly durable. They expressed disbelief in the idea that they could create a similar crèche with local materials. During the pilot study, older children were also interested in the play pen, using it in more socio-dramatic ways than their younger counterparts. However, mothers still believed that this play-yard was too small for long-term use.

With that in mind, the cycle of design development was focused on exploring ways to protect infants but still providing a space for exploration and motor play. How could children, chickens, and contaminated soil be separated while still giving an object to caregivers that was flexible and durable? A set of design goals, derived from architectural programming standards, were tailored to the Zimbabwean context and used for additional imaging development (Figure 3-14 and Figure 3-15).

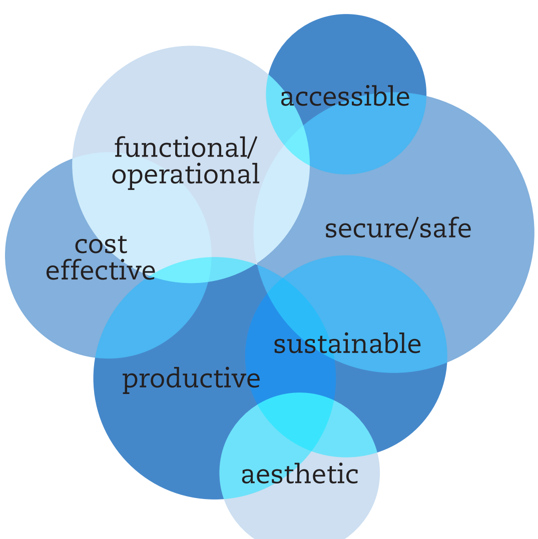


Figure 3-14: program elements

Figure 3-15: design paradigm

Figure 3-16: "Pack and Play" play-yard.

Figure 3-17: "Pack and Play" play-yard detail.

Figure 3-18: Simple gray play-yard.

Figure 3-19: Simple gray play-yard detail.

Figure 3-20: Colorful play-yard.

Figure 3-21: Colorful play-yard detail.

Design Cycle 01

Imaging & Presenting

Imaging consisted of a rough sketching, curating images, and researching prior design benchmarks in play-yards, playgrounds, children's toys, furniture and industrial design, architecture, and outdoor spaces. The initial stage also included an investigation into possible avenues of materiality that included ceramics, mud brick, sand bags, tires/recycled materials, concrete, and wood. The ideation at this early stage involved a general brainstorm of all possible ideas and solutions that were grouped into categories to present to a group of nutrition researchers (Figure 3-22). The sketches were grouped into ideas of ground-cover, hard barriers, soft barriers, flexible barriers, and combination barriers.

From the presentation, some additional considerations were raised. Researchers wondered about the exact location of a design solution in the context of the homestead and worried materials for any design would be misappropriated by families. Misappropriation could be an additional risk if families were required to contribute to part of the cost of the design or if the playspace was difficult to put together or use. Researchers thought that the idea of natural, locally-sourced materials would be attractive to families and funding sources due to availability and relative cost. Materiality consideration was explored in the presentation and was especially salient because the conditions of the context required a rigorous set of performance guidelines. The presentation of so many potential avenues of exploration, however, was overwhelming to the audience and therefore more refinement and consolidation was reiterated.

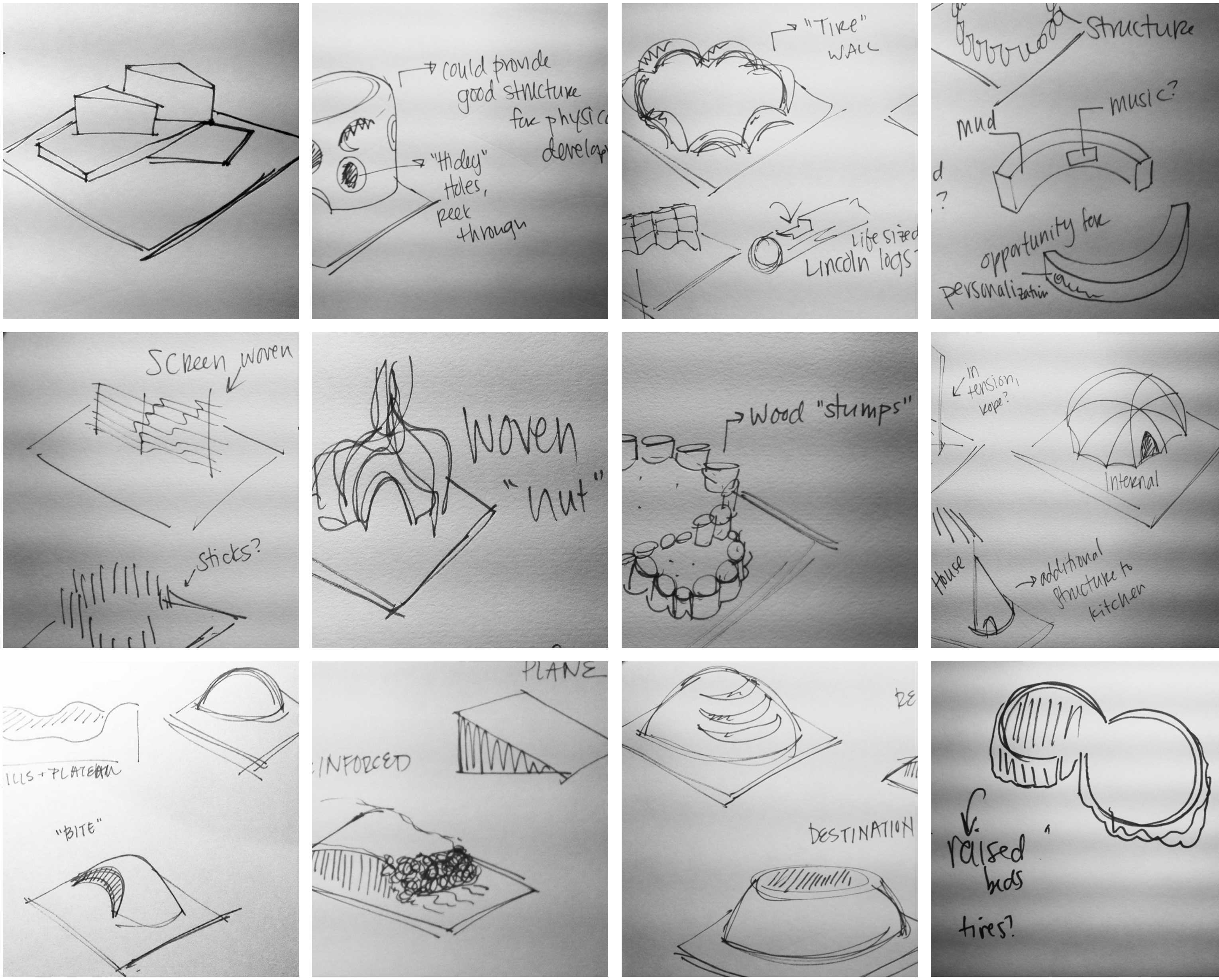


Figure 3-22: Initial brainstorming sketches.

Design Cycle 01

Testing

Testing in the early stage utilized a local student user-experience club to, consisting of about thirty students (MBAs, desginers, and engineers), to brainstorm novel solutions to the protected playspace design problem. The head designer split students into balanced teams and lead the group through a series of human-centered design exercises to tease out new insights on the project brief. Giving student teams basic information about the issue to see if their ideas matched or ran parallel to the design ideas sketched by the designer was also part of the testing process's intent.

With no limits on the kinds of design solutions that could be presented, the teams did not come up with viable options to pursue. However the testing process did highlight different avenues of behavior-change interventions. One team focused exclusively on developing educational cultural icons who could educate children and families on the dangers of eating feces. While rural Zimbabwe does not have the media consumption required for that idea, the focus on older siblings was a key takeaway. Other teams focused on restricting chicken movements or placing gloves on infants to prevent them from picking boluses of feces from the ground. Neither of the ideas presented were feasible but a fourth team went in the opposite direction by proposing a playground for children made of local materials, co-design activities, and geared towards social play. Certain community structures could not support such a playground, but the ideas presented still generated more ideas and strengthened the teams' conviction in rigorous research-based design.

Design Cycle 01

Reimaging

In the midst of the first design development cycle, many additional questions came up for the design and research team. In order to properly separate chickens from children, more information on the roosting, feeding, and defecating practices of chickens was needed. Issues of materiality, feasibility, maintenance, and cleaning were also discussed during the presentation session with researchers.

There were also discussions about specific design ideas that required refinement in future design development loops. For instance, permanent wall structures could become a problem for families who don't have enough resources to build secondary structures on their own homestead. Structural hills, while a robust and desirable form to explore further, could be difficult to build in resource-poor areas with difficult terrain. Any structure could take up a lot of real estate and materials in homesteads that lack space. The variability of landscapes came up in discussions with Zimbabwean researchers in that homesteads could be very sandy, muddy, or contain a large enough number of rocks or boulders to make building long-term or large structures prohibitive. Ultimately, the current design ideas needed to be distilled and consolidated into broader, more feasible ideas.

Section Three

Iteration Two

Informing Design Cycle Two

In design cycle two, the designer looked back at the literature within the field of neurobiological childhood development (Figure 3-23). This was done in an effort to develop a playspace that was stimulating and engaging for infants and toddlers while still being accessible and inviting to siblings, caregivers, and community members. Each category of design in this cycle focused on some aspect of early childhood development to explore the concepts of designing for children further.

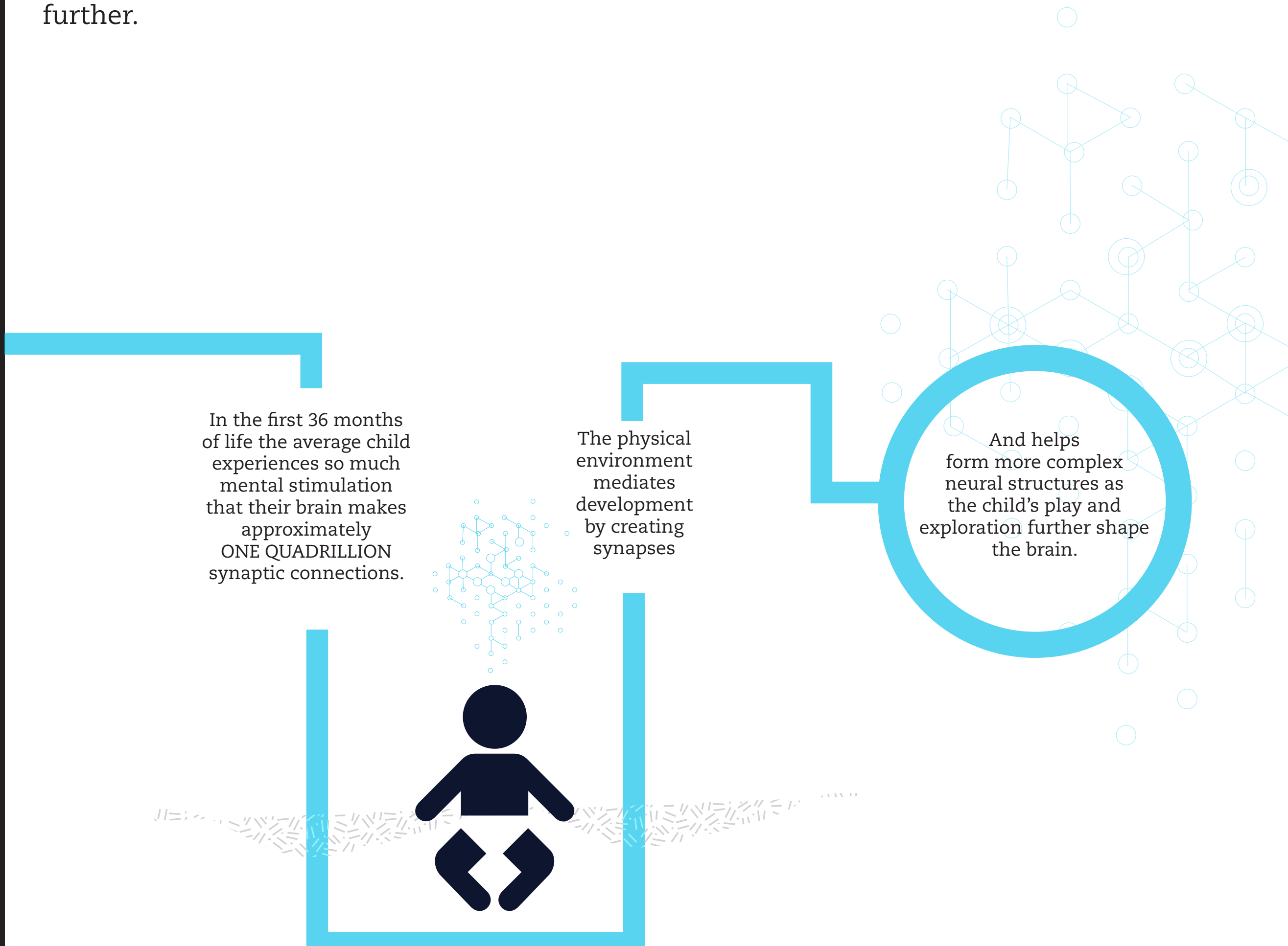


Figure 3-23: The physical environment and development

Design Cycle 02

Imaging

The second round of imaging began to consolidate the previous brainstorming and sketches into a narrower format. In this process, more images were curated to form over-arching concepts. Concepts were used as the underlying framework for design exploration that involved both problem solving and creative visual thinking (Landa & Gonnella, 2001). While brainstorming and sketching are a part of concept development, a heuristic used throughout this project is a process of curating a bank of images and ideas across a spectrum of environments. Words and images co-mmingle in a process of idea generation - both words and images can work interchangeably to fuel the search process and push concept development forward.

Figure 3-24: Grouping design development sketches into concepts.

Design Cycle 02

Presenting: Walls

Creating a protective play space with walls was the first and most obvious exploration due to the vernacular architecture of Zimbabwe. There was a strong precedent of existing structures made of sticks, mud brick, concrete, and plaster. Walls could be made from bricks, stones, super-adobe, wood, stumps, cork, plastics, or recycled materials typically used in playgrounds. At the most basic level, walls could draw on known construction techniques and could be built with seating for additional value. Low walls provide opportunities for older children to play on and decorate, as demonstrated in (Figure 3-27). There could also be a component of personalization for each household either in the painting of structural walls, scratching into plaster, or creating mosaic-type applications that could afford infant exploration and cognitive development. A walled structure could also be created to provide footholds for climbing and cruising young toddlers without risking the structural integrity of the play space (Figure 3-28). However, solid walls typically mean that caregivers could not change the playspace for the growing infant or the potential space constraints in the homestead area. Figure 3-29 attempts to mitigate some of those constraints by creating a wall out of modular blocks that could be rearranged depending on their context. These blocks could follow early childcare center precedents with a solid foam interior and rubberized exterior or explore new materials such as interlocking cork structures (Figure 3-26). Structural walls appeared to be the most basic and inflexible but also probably the most feasible of options.

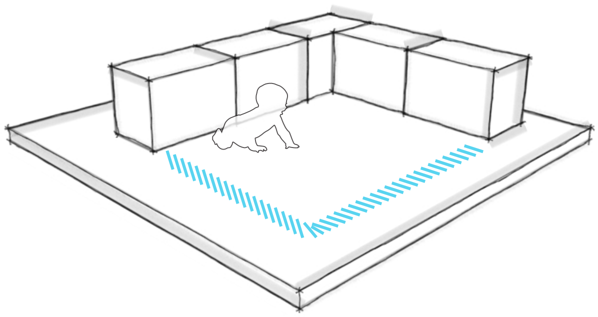


Figure 3-29: Modular block iteration.

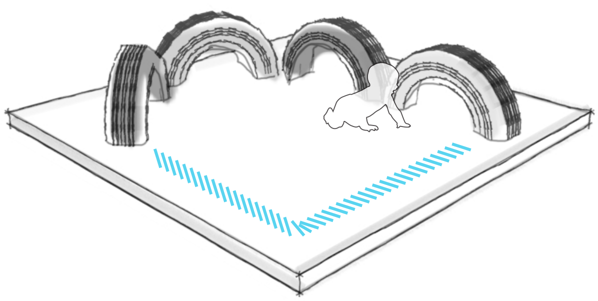


Figure 3-30: Recycled tire iteration.

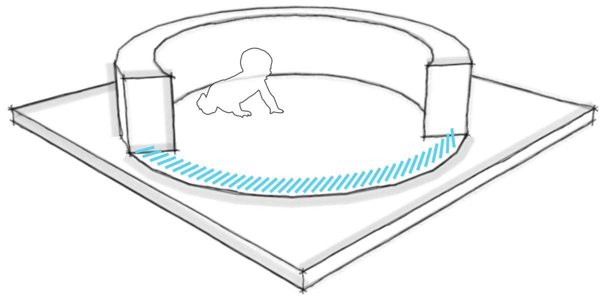


Figure 3-31: Structural wall iteration.

Figure 3-25: Cement Mosaic.

Figure 3-26: Chaise Cork Lounge by D'arc Studio.

Figure 3-27: Children personalizing wall with chalk.

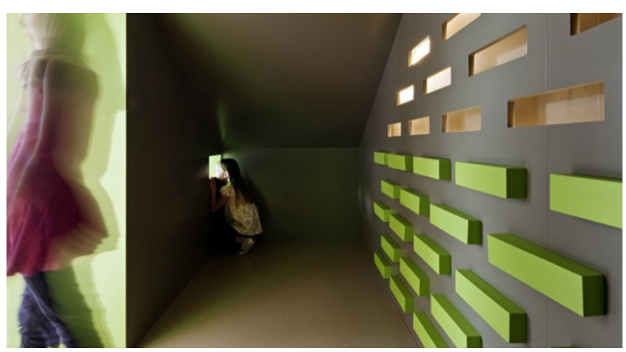


Figure 3-28: Modular climbing wall in a kindergarten corridor.

Design Cycle 02

Presenting: Hills

While wall iterations were derived from man-made buildings, Zimbabwe's rural landscape inspired the development of a modular, hilly playspace. Most of the country is situated on a plateau punctuated by rolling hills. These iterations focused on hills as a geometric construct rather than a pile of dirt so that it becomes a structure that could create interesting spaces with potential for play. Well known in natural children's parks, hill have potential for play because they are steep enough to feel risky, which is vital for motor exploration and confidence development. While hills are created in a very literal way in children's playgrounds, this set of ideations focused on the creation of modular hill structures that could be taken apart and rearranged, much like a three-dimensional puzzle. This flexibility in form would allow for many configurations to suit the needs of each homestead. The blocks could be permanent, made of mud-brick and local materials, or made of thick foam as found in some preschool settings. However, space constraints in rural Zimbabwean homesteads could still be an issue and numerous components could be cost prohibitive.

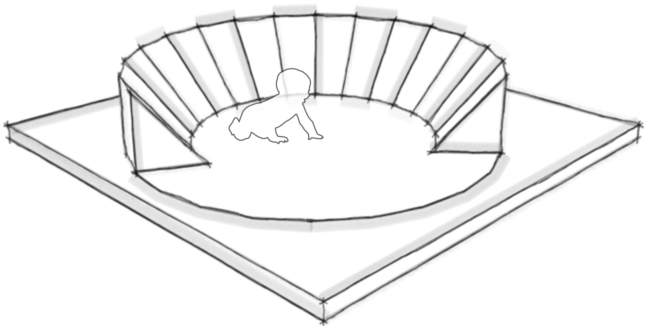


Figure 3-36: Modular amphitheater iteration.

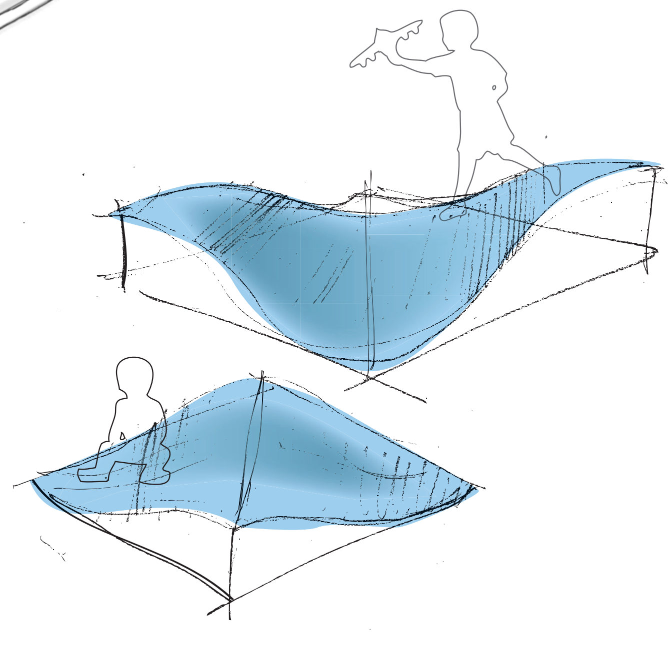


Figure 3-37: Modular hill iterations.

Figure 3-32: Myriad crash pad by Mike Vinson.

Figure 3-33: Safe Zone by Stoss Landscape Urbanism.

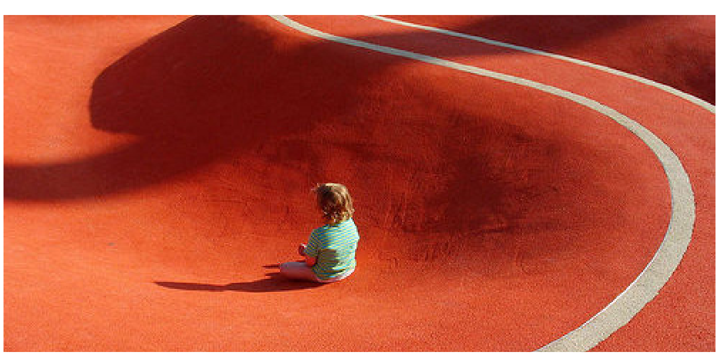


Figure 3-34: BUGA Playground rubber surfacing by Rainer Schmidt.

Figure 3-35: Jean Dubuffet Jardin d'email.

Design Cycle 02

Presenting: Screens

Reducing the wall concept further led to exploration of screen systems. Zimbabwe has a healthy weaving tradition which fed into the concept of a wall that was woven or textile-based. Screens offer flexibility in materials, form, and afford movement from one location to another. A track in the ground could provide an easy template to put the playspace back together quickly and an accordion structure aims for easy storage. Local craftspeople could be contracted to create the woven structures. However, the hassle of putting the playspace up and down could override the usefulness of keeping infants contained and safe. Another risk is that toddlers often grasp onto objects in their environment to pull themselves up and the screen method presents issues of sturdiness.

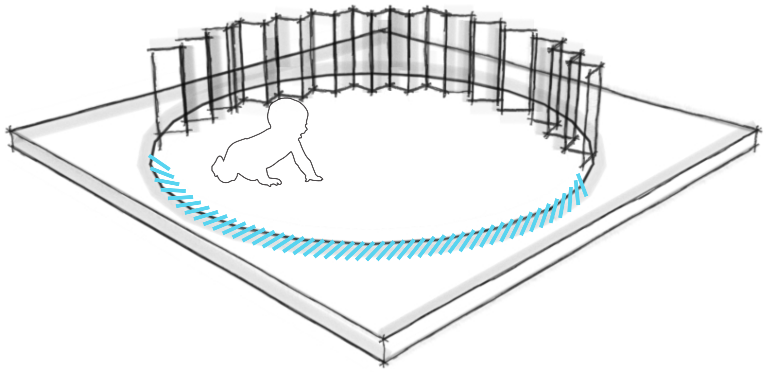


Figure 3-42: Screen/Accordion iteration.

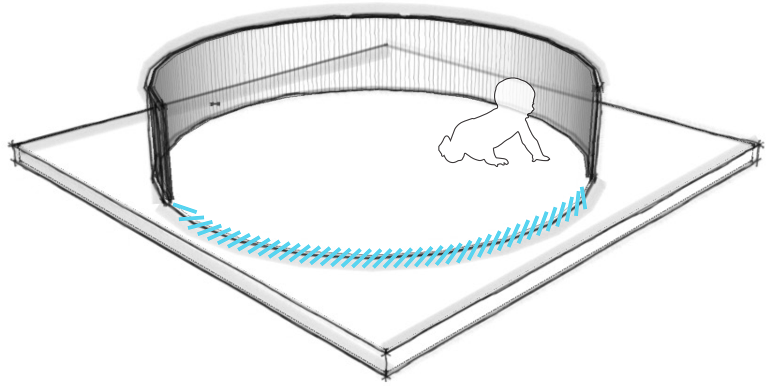


Figure 3-43: Simple screen iteration.

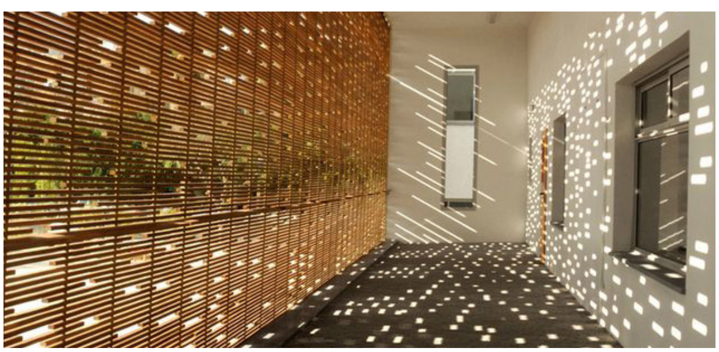


Figure 3-38: Remez Arlozorov by Mayslits Kassif Architects

Figure 3-39: Kindergarten in El Serrallo by Elisa Valero Ramos

Figure 3-40: Windfisher by Elaine Parks.

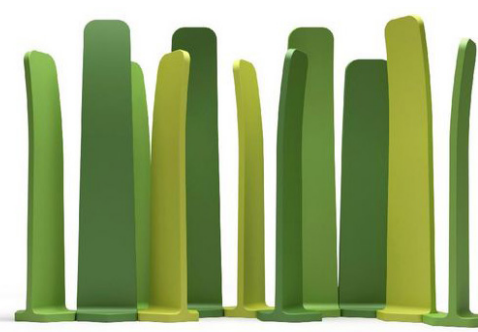


Figure 3-41: MUT Design product room divider.

Design Cycle 02

Presenting: Tensile/Textile

User interest in flexibility pushed ideation into iterations of tensile structures. Tents also have great potential for movement from location to location. Based on the ideas of cliff-tents, playscapes generated from this concept could be made to fit the wide variety of Zimbabwean homestead landscapes, which range from exceptionally rocky to flat and dusty. Tents can provide some protection from rain and sun and could be treated with antibacterial products prior to delivery. An inverted “hammock” style tensile structure could allow the fabric to act as both walls and the floor where it touches the ground. Textiles based in Zimbabwean tradition also connect the structure to the culture in which it resides. Unfortunately, there are increasing issues of sturdiness, installation hassles, and fewer opportunities for motor play with tensile structures.

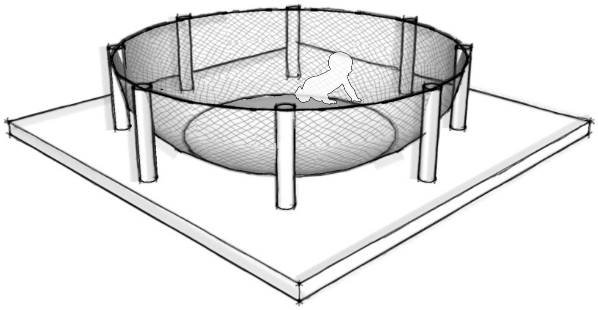


Figure 3-48: Tensile "hammock" iteration.

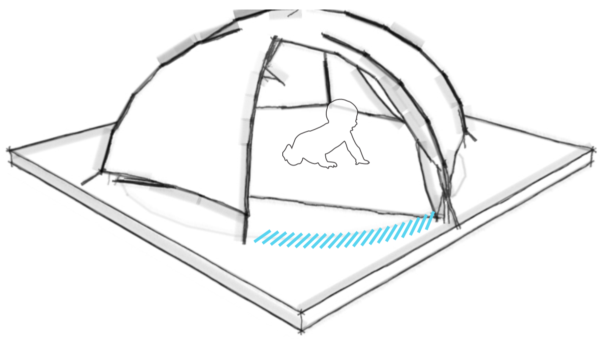


Figure 3-49: Tensile tented fabric iteration.

Figure 3-44: Crypton anti microbial textiles for infants.

Figure 3-45: Kidco PeaPod.

Figure 3-46: Caterpillar camping tent.

Figure 3-47: Toshiko Horiuchi crochet-playground.

Design Cycle 02

Testing & Reimaging

This round of testing consisted of talking with an anthropologist and ergonomist on how the different concepts of play spaces could be translated across cultures and children. Such a conversation was especially important as the ideas would be taken to Zimbabwe and verbally and visually "tested" on local caregivers and researchers. As there were few written ethnographies of the regions of rural Zimbabwe, an anthropological perspective on how to observe cultural details provided the means to focus on the superlatives of a culture. That is, a designer needs to pay attention to the visual details present in everyday life.

An issue with the walls and tensile iterations was the concept of isolation, and how that could come across as a negative element to parents. A benefit to tents is that they could reflect the local culture's textile traditions and be imbued with color for child development. In the same vein, mats could provide color as well as tactile exploration through different surfacing techniques and textures. In moving towards designs with more structure, hills are a common desirable feature among children that typically will not change across cultures. The testing revealed that additional exploration in Zimbabwe needed to develop a structure that sought to resemble familiar things to the culture.

These ideas were rehashed in various ways. While the four basic concepts were integral to design development, none of them adequately addressed all of the users' wants or needs, leaving questions that needed direct user input.

Flexibility Spectrum

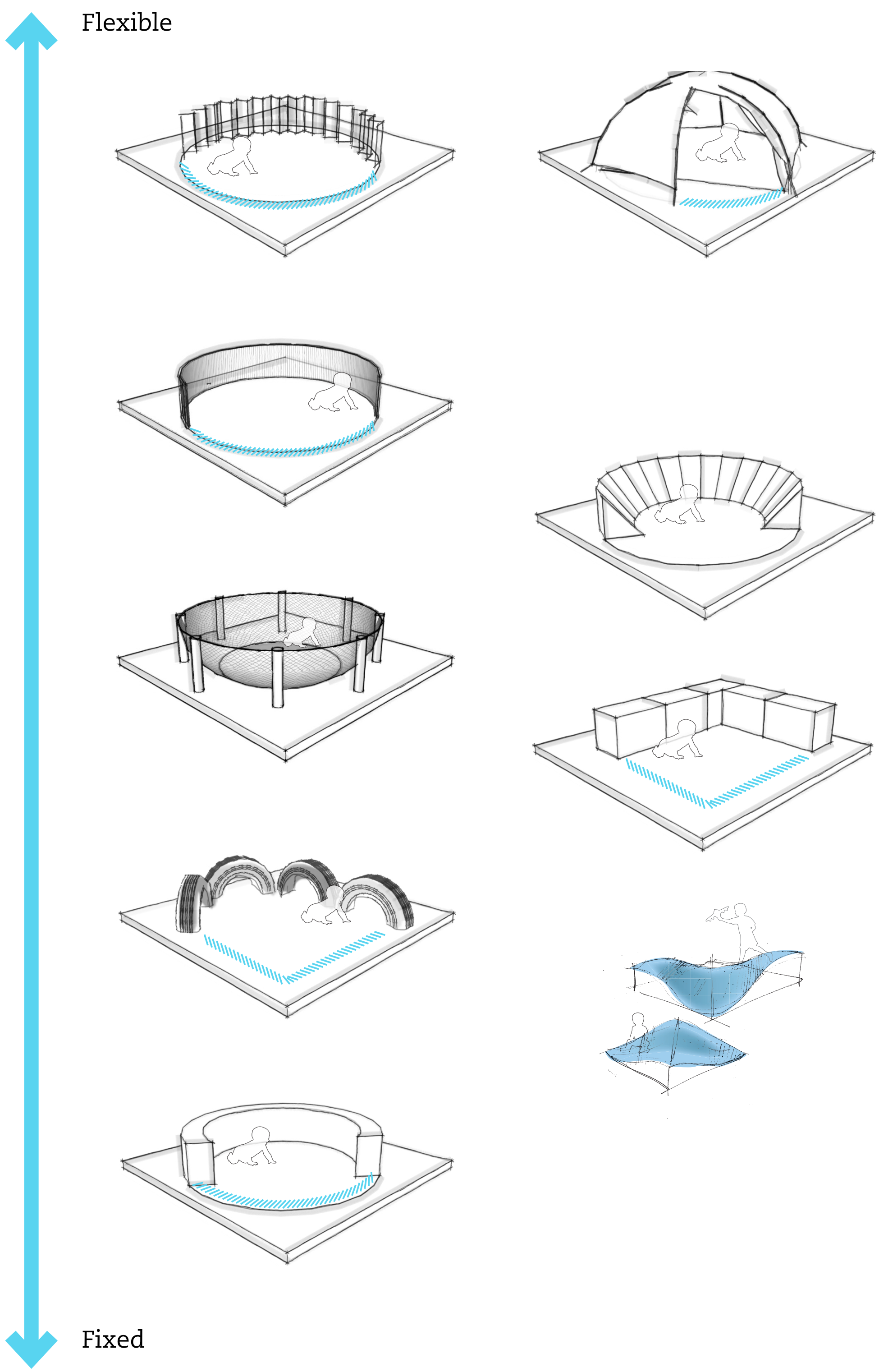


Figure 3-50: Cycle Two flexibility spectrum.

Section Four

Iteration Three

Informing Design Cycle Three

Figure 3-51: Members of the Ministry of Maternal & Child Health, Zimbabwe

Design Cycle Three began in Zimbabwe and lasted a number of weeks both in and out of the country itself. The first goal was to update the team in Zimbabwe on current developments in the project and interview the researchers in-country. Another objective was to make connections with the Ministry of Child and Maternal Welfare. This government agency facilitated transport to and around rural areas in Zimbabwe. The team interviewed Zimbabwean parents in rural districts northeast of Harare about the play habits of children aged eight to thirty-six months. The information gathered confirmed what was learned from the play-yard pilot study and also revealed key differences between how the male researchers and female caregivers perceive daily homestead life in rural Zimbabwe.

The researchers who were the interviewed had conducted the initial play-yard pilot study. Their first concern was that parents would not be interested in a dedicated space for their children and would re-appropriate materials to other

Design Cycle 03

Information Input

structures around the homestead. To combat this, the researchers suggested that the structure should either be fixed in place and resemble a miniature hut or be constructed of wood or grasses in such a way that the materials could be re-used as fencing when the child was old enough not to need a play-yard. They also believed that mothers on a whole could not devote time to personalizing the homestead. However, when interviewing rural mothers, it became clear that mothers wanted a dedicated structure for their children that was durable enough to pass on to other mothers or keep for their grandchildren. Mothers preferred a structure that could grow with their child and could be moved or stored around the compound. The personalization evident around all of the visited homesteads presented another contradiction and informed the next cycle of imaging.

Interview Questions for Researchers & Caregivers

Home Setup

- How many people live in your home?
- What do different household members do?

Home Activities & Context

- What is a day like in your home?
- What kinds of things do children and adults do differently?
- Can you describe the process of feeding your baby?
- When your baby dirties its nappy, how easy is clean-up?
- How much space does your baby use to crawl/walk in?
- Who plays with your baby? How do they play with them?
- Do you see your baby at all times?
- What does your baby use to pull itself up on?
- What's the easiest thing about caring for your baby? The most challenging?
- What do you like to learn about child development?

Playspace specific

- If you did have a playpen, how much/how long would you use it?
- Where in the homestead would you want your baby to play?
- What would you like the play area to look like/have?

Table 3-1: Sampling of interview questions for field interviews.

Figure 3-53: Rural ZImbabwean general store.

Figure 3-52: Rural Zimbabwe countryside.

Figure 3-54: Example of fencing techniques.

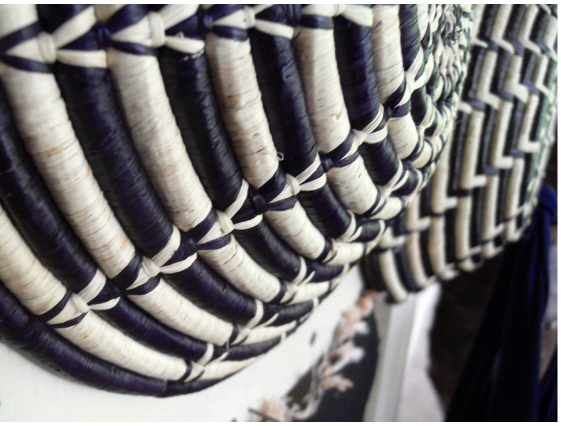


Figure 3-55: Traditional basket weaving.

Figure 3-56: A preschool classroom.

Figure 3-57: Entrance of a rural home.

Opinion Comparison of Researchers & Caregivers

Thoughts from Researchers Researcher's ideas of what mothers want in a protective play space.	Insights from Mothers Thoughts from potential users from interviews with mothers
Fixed in place	Moveable/storable
Static	Grows with child
Re-appropriation of materials	Interest in long term use/sharing
No interest in personalization	Personalization at homestead
Multi-use objects	Want a child-designated object

Table 3-2: Comparing and contrasting opinions of researchers versus mothers.

Design Cycle 03

Imaging

Imaging in this cycle consisted of conducting an informal visual ethnography of Zimbabwean life and culture (see figures on previous page) in order to inform further details or spur creative leaps in the design process. Visiting local craftspeople sparked an image exploration drawing on the concepts of weaving and baskets. Further exploration consisted of “taking the basket apart” or dissolving the form to create gaps in components that could be woven together. Research into additional playground precedents revealed the PlayHive (Figure 3-58), a series of wood planks bolted together in a similar woven structure. The designer transposed the idea into pieces of wood that could be hinged with a dowel or similar pin-hinge. Depending on the size of the wood pieces, the structure could afford children grabbing and pulling themselves up to walking positions. Future iterations could also potentially roll up into a shape that would be easier to transport and transform. For presentation purposes, some design principles of the playspace was conceptually driven by the structural properties of corn as well as corn’s inherent cultural significance across Zimbabwe.

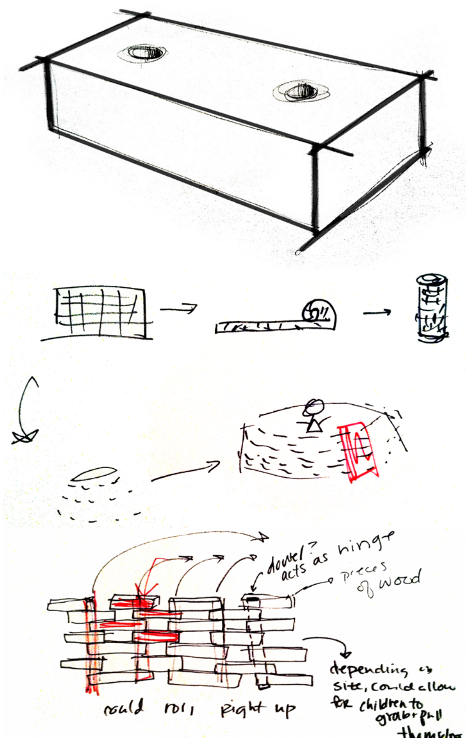


Figure 3-59: Sketches inspired from baskets.

Figure 3-58: 'PlayHive' Playhouse by thoughtbarn

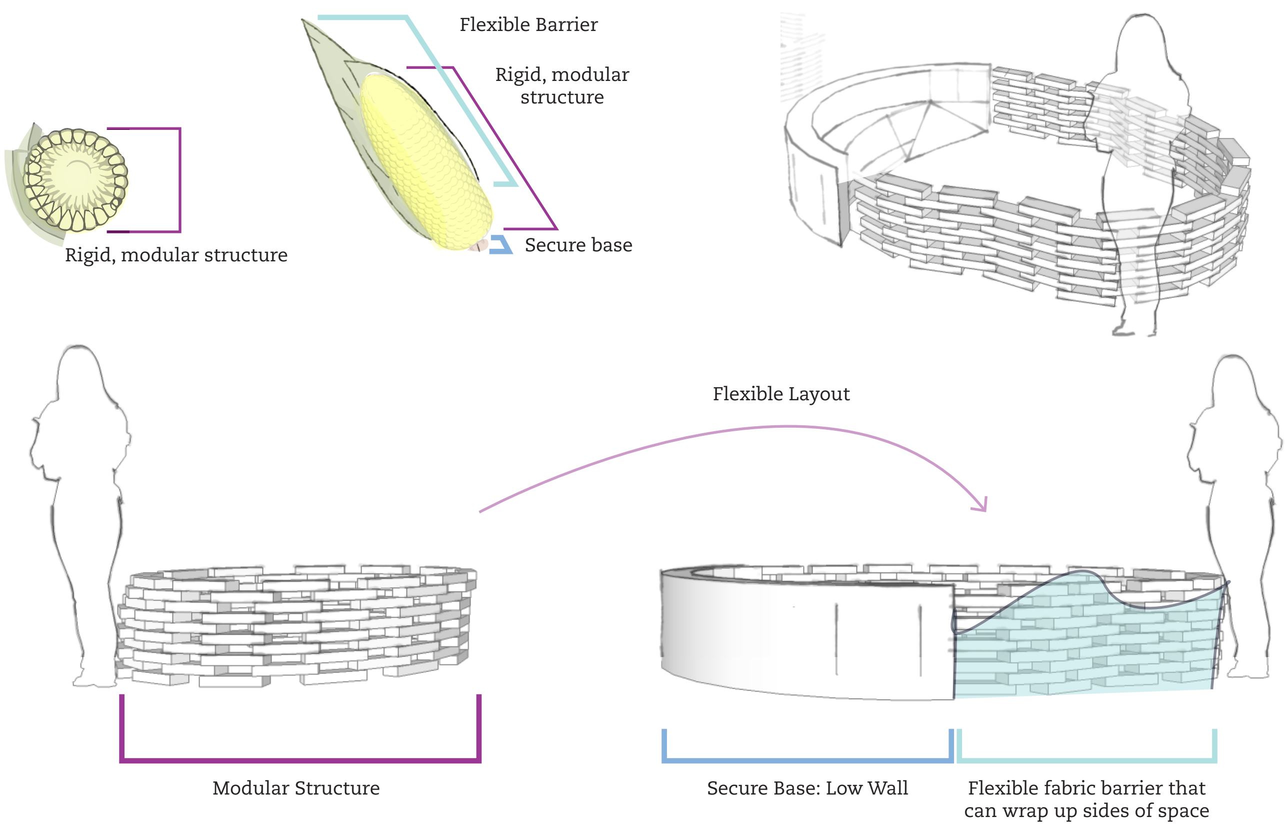


Figure 3-60: Playspace iteration based off of maize conceptual framework.

Design Cycle 03

Presenting, Testing, Reimaging

During the presentation and subsequent testing discussion, the context of the project - as the research team thought of it - began to modulate and deepen. Though the project started with environmental enteropathy in developing countries, a more layered and nuance context was presented with design development to include family structure, other children, child development, and culture. The matrix of performance requirements allowed the team to ask about positive and negative outcomes. While negative outcomes had more context and were easier to discuss because they focused on safety and neglect issues, the efficacy of positive design features became clear to the team during the structure's presentation and decision matrix discussion. This resulted in a slightly more refined matrix of performance requirements that would inform future cycles.

how would a child interact in the space full scale?

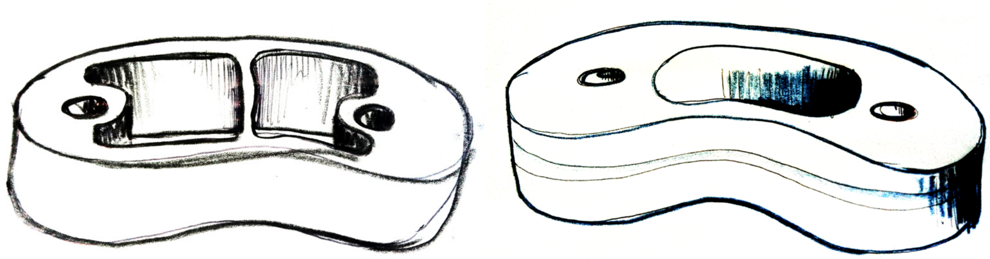


Figure 3-61: "Kidney Bean" style component sketches.

Matrix of Possible Performance Requirements

Categories	Approaches & Options			
dirt barrier	ground cover (mat)	secure base	ground cover (textile)	anti-microbial
vertical barrier	animal protection	un-perchable by chicken	insect protection	well protection
sun/heat barrier	textile tent	open air	location (structure/tree)	
product injury	US safety standards	European standards	International Standards	
gross motor play	ramps/hills	ledges to pull up on	enticing toys for crawlers	variety of textures
fine motor play	shapes	textures	3D	2D
cognitive play	shadow play (movement)	color	sound	
social interaction	multiple children	older children in/out	visual access for mother	integrated in homestead
grows with child	size	developmentally		
portable	weight	non-cumbersome	take down/set up	
durable/rugged	water resistant	fire resistant	termite resistant	child resistant
flexible for terrain	sandy	clay	rocks	
storage	outside	kitchen area	sleeping area	other
personalization	screen/canvas	paint	mud-brick mosaic	
local materials	mud brick	wood	manufactured composite	bamboo
construction (skill)	low - families	medium - trained VHW	medium high - craftsman	
cost	low	medium	high	

Table 3-3: Performance requirements options presented to research group for feedback.

Matrix of Preferred Performance Requirements

Categories	Approaches + Options			
dirt barrier		no dirt barrier		
vertical barrier	animal protection			well protection
sun/heat barrier		open air	location (structure/tree)	
product injury			International Standards	
gross motor play	ramps/hills	ledges to pull up on		
fine motor play	shapes	textures	3D	
cognitive play	shadow play (movement)	color		
social interaction		older children in/out	visual access for mother	integrated in homestead
grows with child	size			
portable		non-cumbersome	take down/set up	
durable/rugged				TBD
flexible for terrain	sandy	clay	rocks	
storage				TBD
personalization		paint	mud-brick mosaic	
local materials	mud brick			Other, TBD
construction (skill)		medium - trained VHW		Other, TBD
cost	low			

Table 3-4: Narrowed set of performance requirements based on researcher feedback.

Section Five

Iteration Four

Informing Design Cycle Four

The current design looks to integrate into the homestead and culture by the placement of the play space as well as being sensitive to the culturally-specific play and family structures in rural Zimbabwe. This includes designing a space that invites interaction from multiple children and a space that demonstrates respect for the natural environment that children develop in. It's a solution that seeks to utilize local materials and respond to the community's visual vocabulary. Protect, stimulate, and interact were three heuristic principles loosely based on the guidelines to help inform further design iterations on a basic level. This cycle was therefore informed both by a distilled version of design goals as well as the cultural insights from Zimbabwe in the previous cycle.

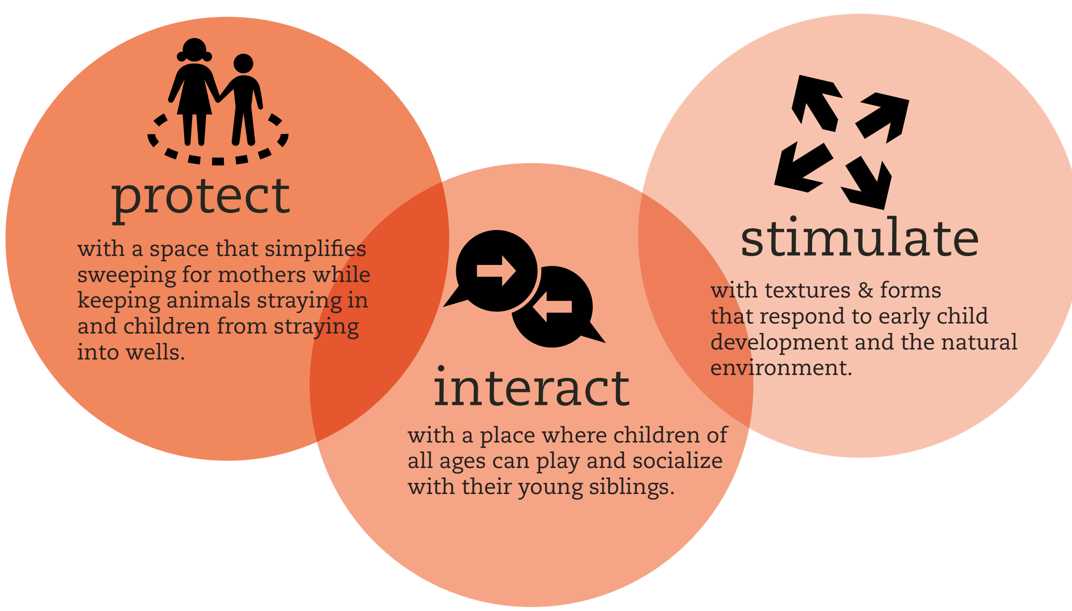


Figure 3-62: Protect, Stimulate, Interact - developing design principles.

Design Cycle 04

Imaging

This cycle continued to develop the modular goals of the previous cycle's design iteration by incorporating more development around materials, shapes, and sizes of interlocking components. The "Lego" stacking principle continued in this iteration for easy reconfiguration and replacement of missing or broken parts. This iteration takes the metaphor of corn further by deriving a softer, rounded shape from the corn kernels themselves. The rounded edges protect infants and toddlers from injuring themselves on sharp corners while referencing the homestead's natural surroundings. The dimensions for individual bricks were developed from body-measurements of young children and toddlers (Table 3-5). There were still questions at hand - how would a child respond to the structure at full scale? Could the playspace be done in a low-tech (e.g. 2x4 blocks) and a high-tech (manufactured bricks) way depending on what the context called for?

This imaging cycle also defined the playscape in the homestead as a fully three-dimensional landscape space in which purpose-designed components worked together to provide an integrated play experience.

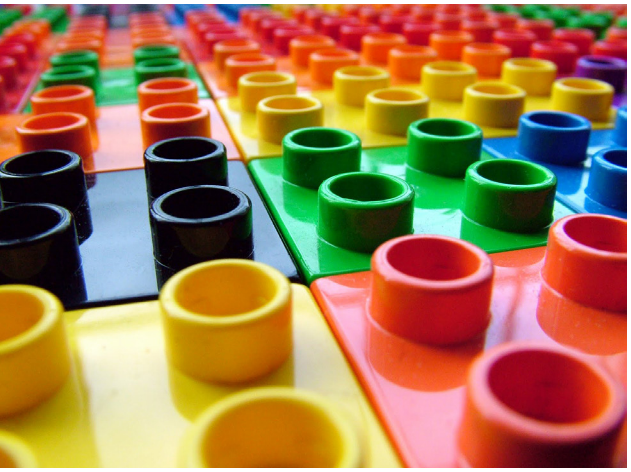


Figure 3-65: Lego brick inspiration.

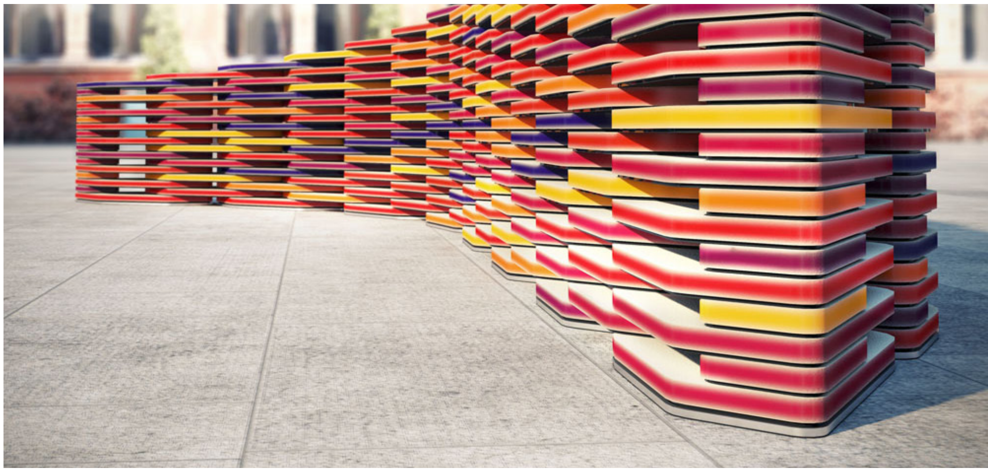


Figure 3-64: AL_A's ceramic bench of plates (detail).

Figure 3-66: Fireplace by Haugen/Zohar

Figure 3-63: AL_A's ceramic bench of plates.

Infant & Toddler Anthropometric Measurements

Hand Width: 1.5 - 2.5" Hand Length: 2 - 4.25"	Foot Width: 1.5 - 2.5" Foot Length: 3- 5"

Table 3-5: Anthropometrics of Infants and Toddlers (Ruth, 1999).

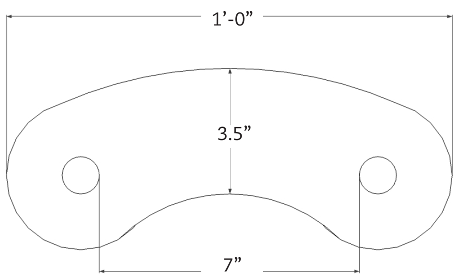


Figure 3-67: "Bean" Measurements

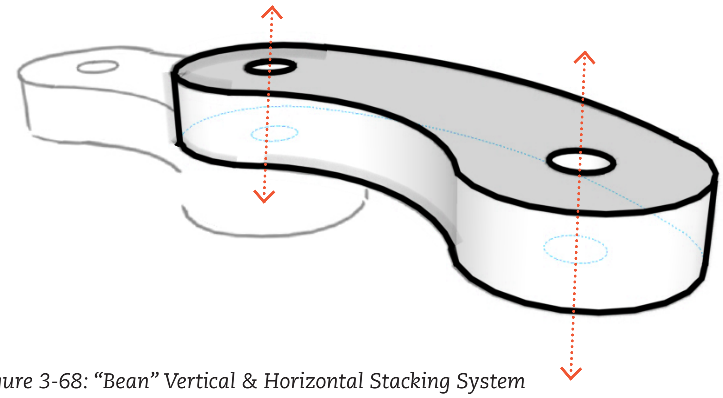


Figure 3-68: "Bean" Vertical & Horizontal Stacking System

Design Cycle 04

Presenting

This round of presentations suggested integrating the playspace by setting it up as an attachment to the main kitchen structure on homesteads (Figure 3-12). Kitchen huts are the first structures to be built on new homesteads and serve as the hub of the family. This way the playspace allows the infants and toddlers to stay connected to the central daily activities. The proximity to kitchen also provides shade, some protection from the elements, and reduces material costs by removing the need to have an additional component on the playspace. In an additional effort to reduce material costs, this round also suggests that a ground barrier might not be necessary if the space itself is kept clean. Attaching the playspace to the kitchen also allows for the creation of some small level changes next to the kitchen wall to afford gross motor development for children while keeping the "bumps" out of the way of adult tasks.

The shape and size of the gaps between each "bean" brick allow for gross motor play and fine motor at all ages as children can pull themselves up on and climb with small hand-holds on the structure. Children at young ages also enjoy tucking objects away, which the openings provide for. The screen-like nature of the gaps can create shadow patterns along the ground and increase visual interest for infants and toddlers. The gaps are small enough that chickens will not be able to roost. The gaps have also been design to prevent entrapment of children's heads.

A pin hinge structure made of metal or some sort of cord system make the structure easier to move, store, transport, and fit into different terrain types.

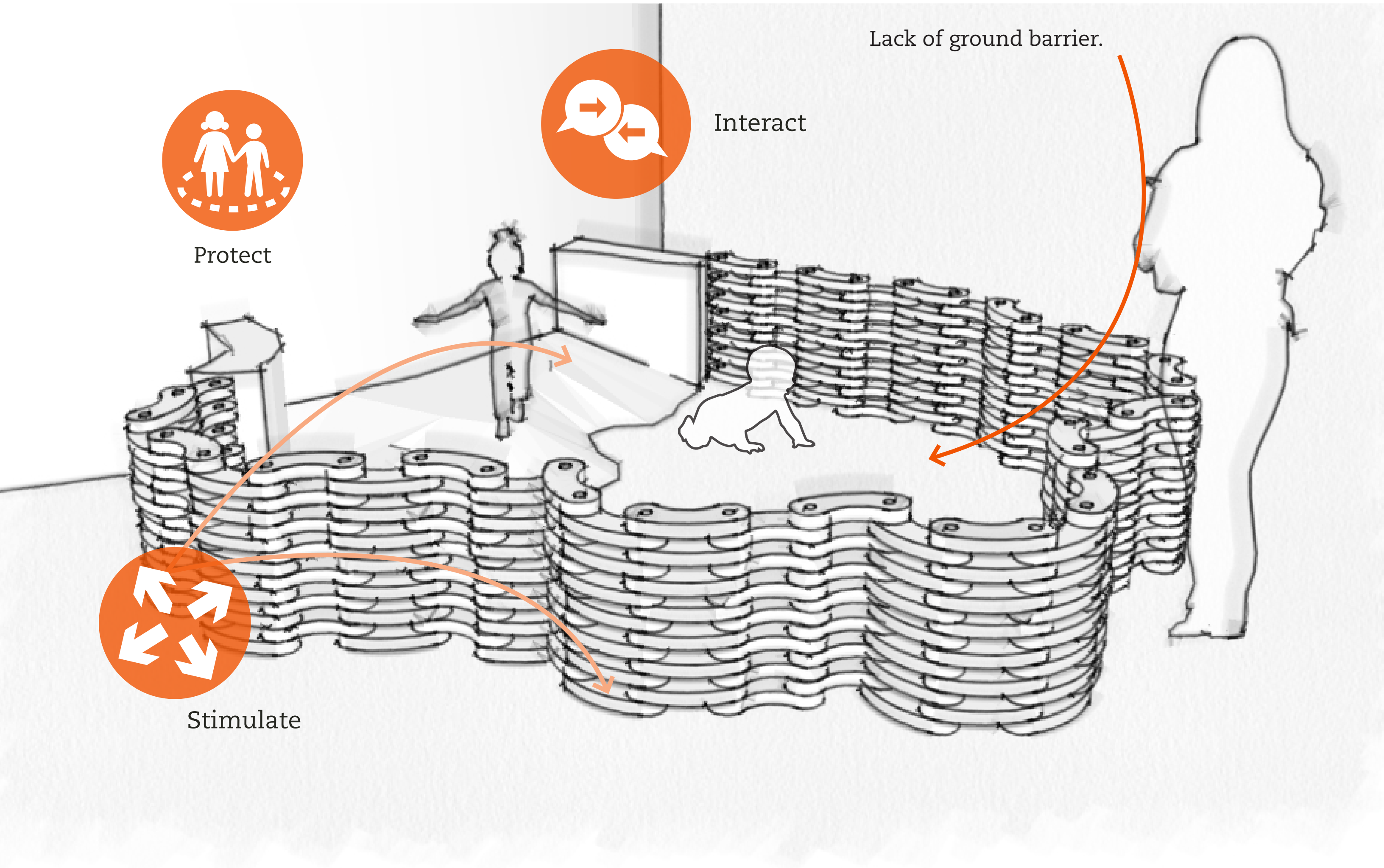


Figure 3-70: "Bean" Brick Playspace digital model.

SUGGESTED PLAYSPACE LOCATION

Compound Sizes:
Lower range: 20 x 20m
Upper range: 50 x 50m

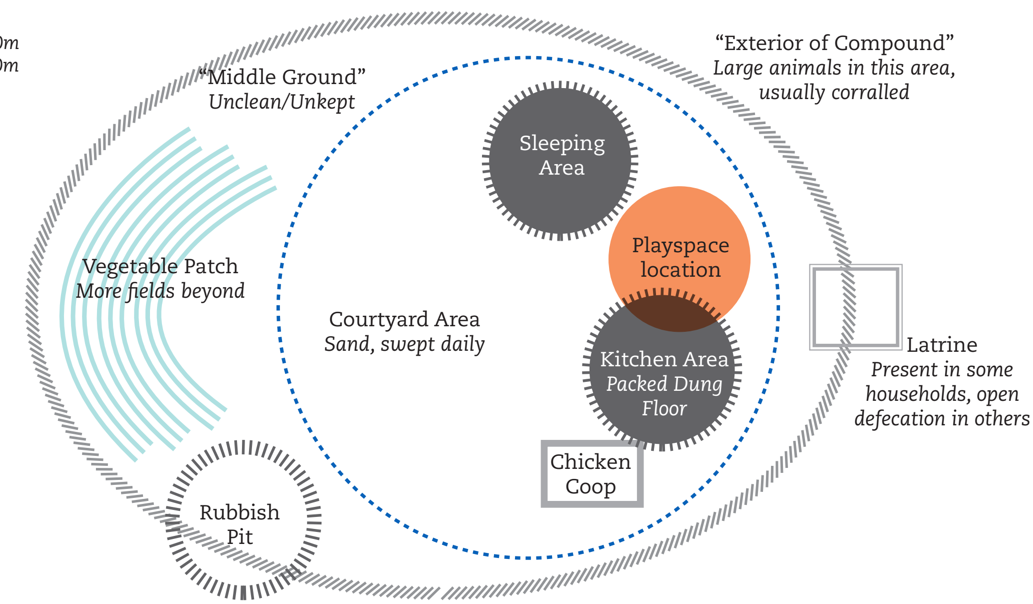


Figure 3-69: Playspace located next to kitchen structures in homestead.

Design Cycle 04

Testing & Reimaging

This round of testing emphasized the usefulness of technology in testing and protoyping. While digital models are helpful to some extent, tangible experience with the mock-up give insights that can not be gleaned from drawings alone. Physical models, especially when they can be rapidly prototyped with laser cutting and machine routers, can give quick insights and answer questions that digital models raise. Furthermore, while the structure of iterations make testing seem straightforward, but there continued to be a lot of back-tracking and convoluted ideas around prototyping. Testing is not a simple loop of a process. Sometimes new ideas arise to eliminate other options and sometimes ideas take shape together.

In this round, issues discovered with the form included issues with construction, packing, and shipping of the "bean" shaped bricks. During the end of this design loop, two separate sets of brick shapes were mocked up concurrently to explore how to reduce waste and increase modularity in curvilinear shapes. Figure 3-71 is a minor conceptual shift from the "bean" shape that continued into the final design iteration loops.

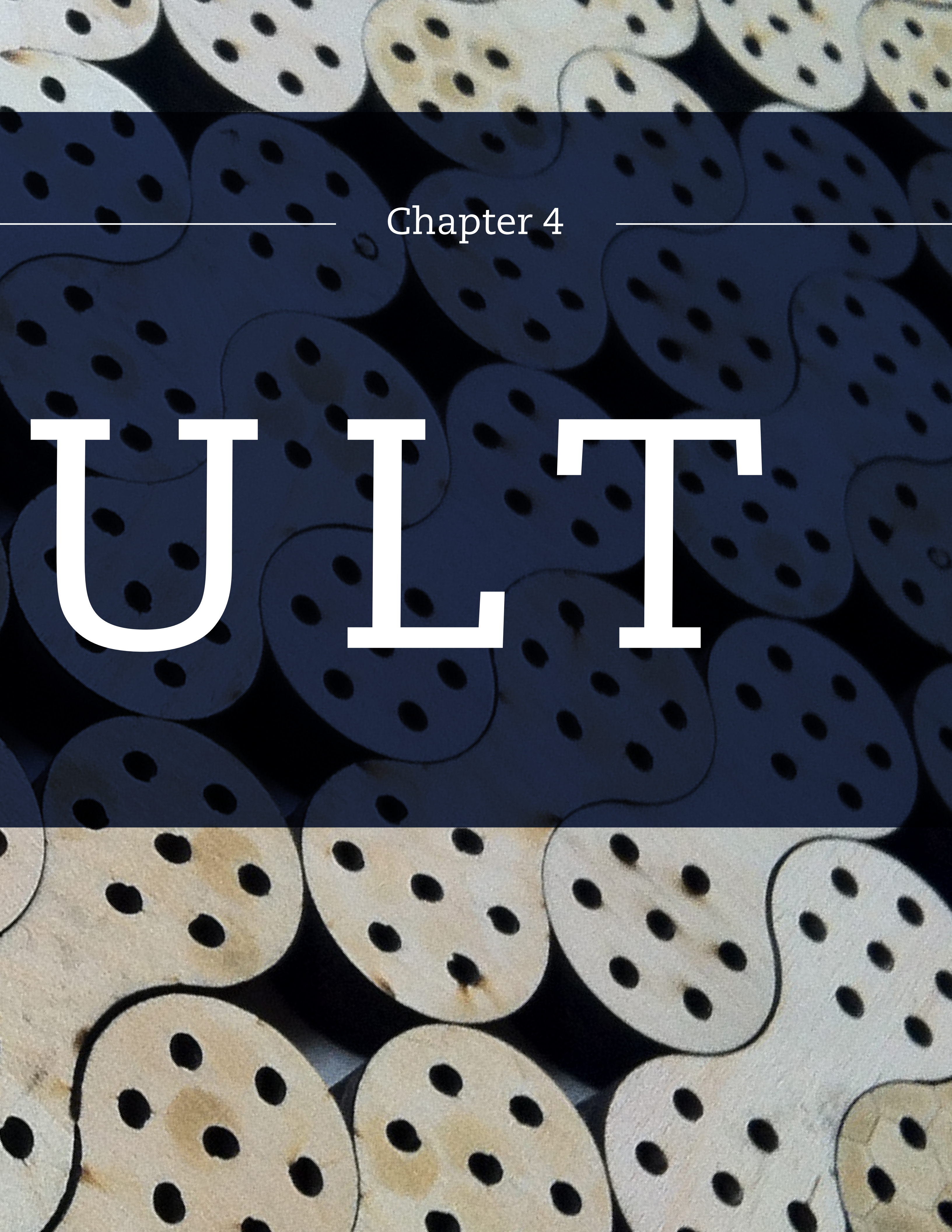
Figure 3-71: "Brick" prototype initial sketch.

Figure 3-72: "Bean" prototypes in wood.


RES

Chapter 4

ULT



Section One

Focused Iterations

Introduction

Within the Design Development Spiral, iteration loops begin to fall within the "domain of acceptable responses," which indicates a possible design solution that could be built and cultivated further to create the final product. Much can said for concurrently looking back and looking forward in all of the process loops. Perspective and forethought are needed in equal quantity because the multiple rounds of testing require attention to detail and a critical eye. This set of focused iterations came from multiple conceptual jumps to strengthen the designer's conviction of an acceptable solution.

In this project cycle, the location of the structure next to the kitchen and the suggestion of gentle landscape modifications to accommodate gross motor development are kept while the modular pieces and hinge points were explored further. The modular pieces developed further in Cycle Four were developed from a gentle curve to a symmetrical wave shape. This increases the "footprint" that the shape makes and therefore increases the stability of each shape. The symmetrical nature means that it can be arranged in any way and makes shipping, stacking, and transport easier. The form is essentially a simple extruded form, with the lightness present inherently in the shape rather than carving out cavities in the middle. Furthermore, the curvilinear shape reflects local buildings and vernacular

Figure 4-90: Bricks highlighting shear issue.

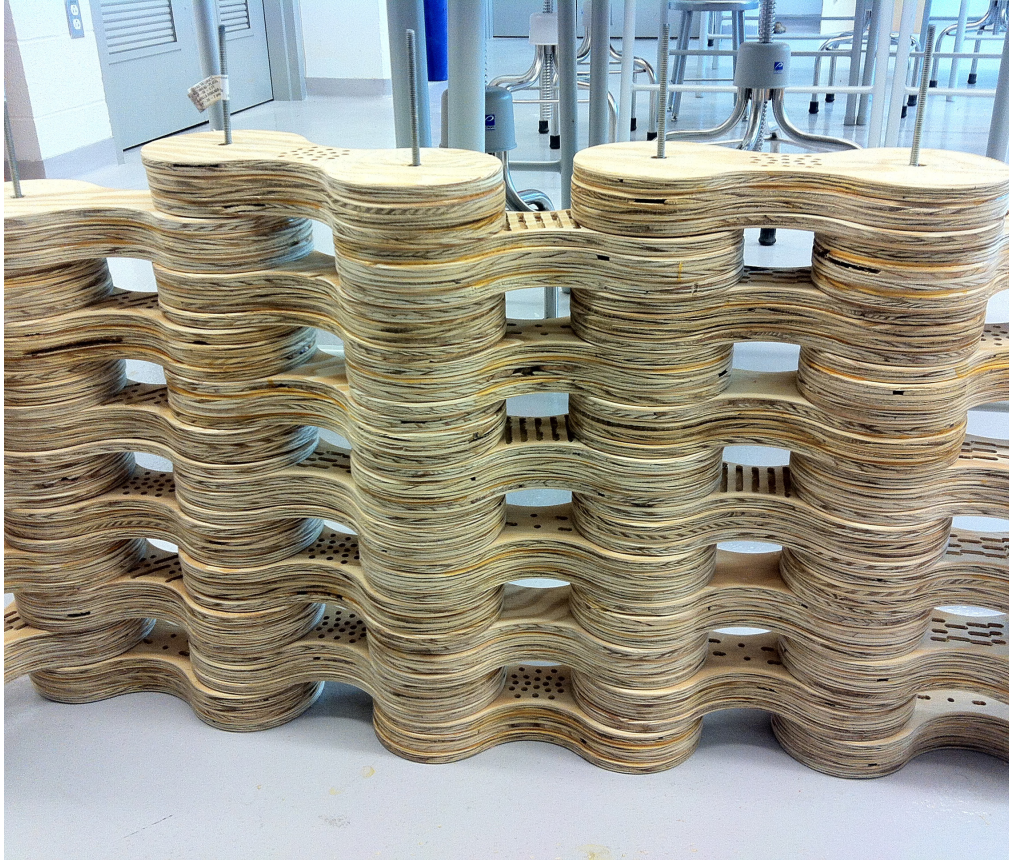


Figure 4-91: Bricks constructed with single center hinge.

construction on homesteads.

At first, the size of the new bricks were the same length (twelve inches) and thickness (two inches) of the “bean” shaped bricks in earlier design iteration loops. In an interest to increase stability and decrease the number of bricks needed for each playspace by about half, the size of the bricks was scaled up to twenty-one inches long and 3.5 inches thick to increase the surface area of each brick. The new scale then put the bricks between the smaller size of toys for children and a larger size of structures for public playgrounds to fit within the context of an extended family homestead.

Figure 4-92: Bricks with two pegs.

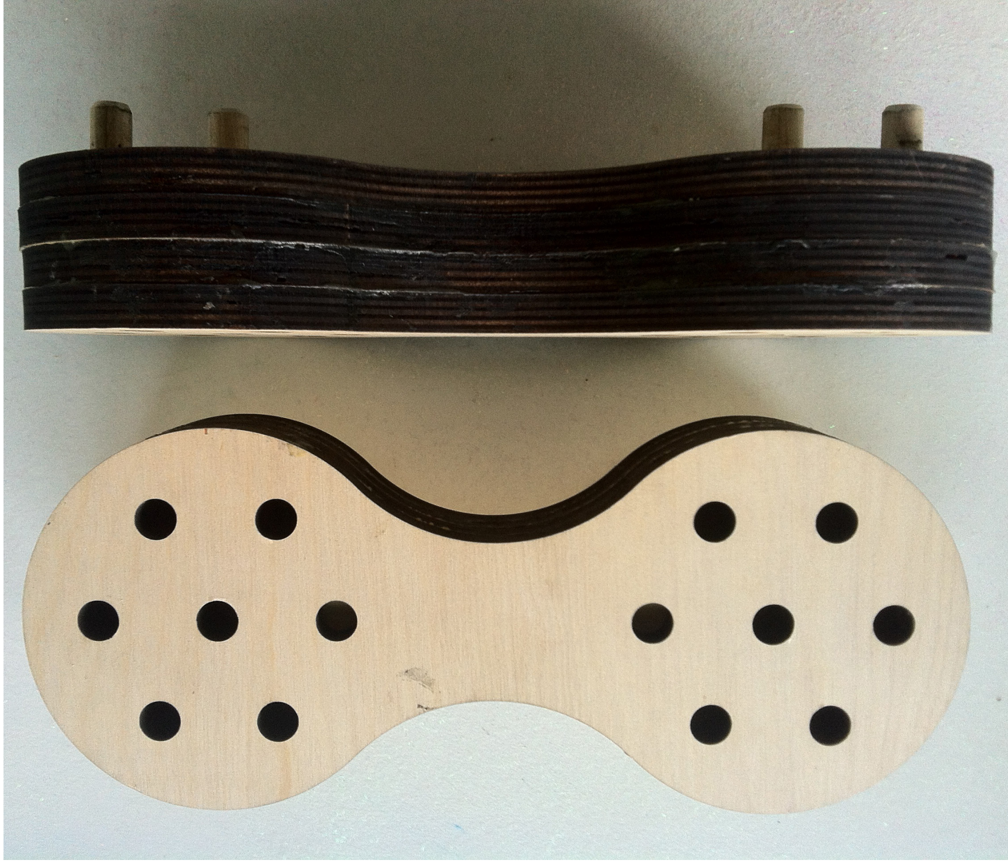


Figure 4-93: Two bricks with pegs, top and profile view.

Figure 4-94: Two bricks with pegs, assembled incorrectly (offset).

Figure 4-95: Two bricks, assembled correctly (one angle option).

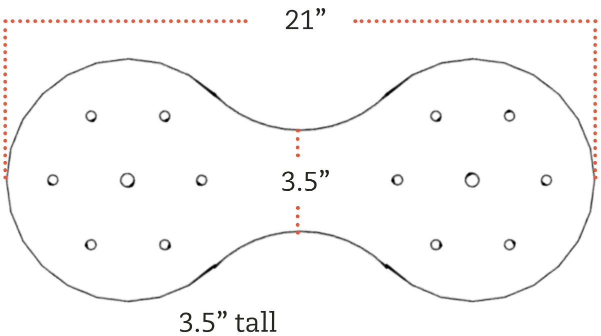


Figure 4-97: Enlarged brick size.

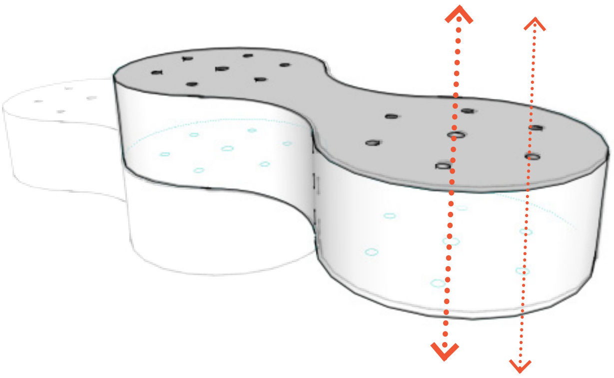


Figure 4-98: Stacking bricks with two points of attachment for poles.

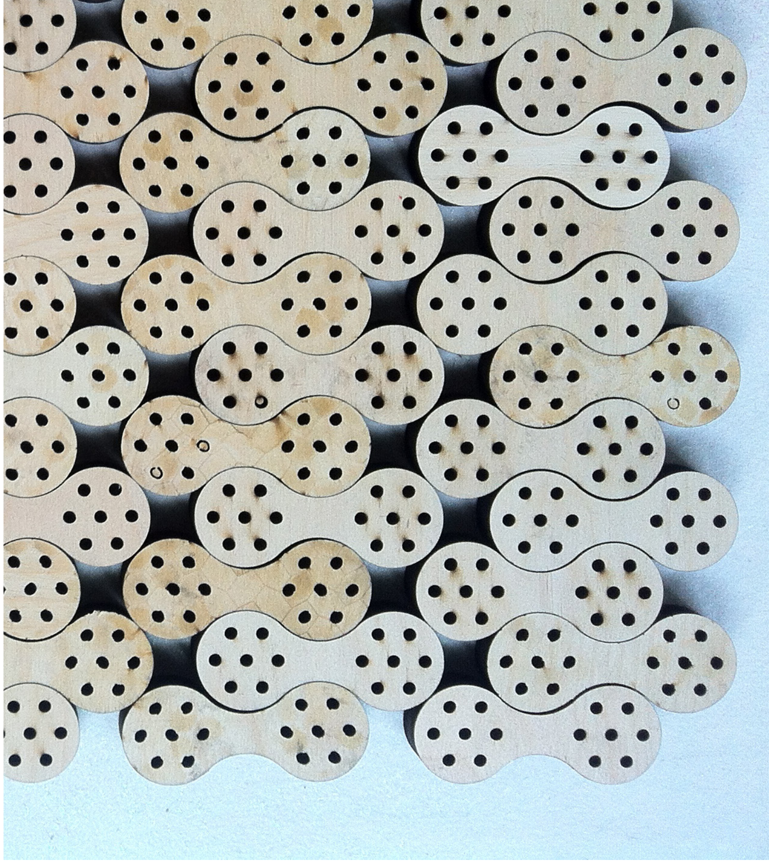


Figure 4-96: Miniature, laser-cut bricks.

Hinge Points

The initial “bean” iterations and the first brick iterations had only one hole as the point of attachment in a pin-style hinge (Figure 4-91). While one central hinge did provide a lot of flexibility when stacking the bricks together, the single hinge also was prone to pivot even when constructed (Figure 4-90). This presented an issue of rotating bricks and the potential to shear and catch children’s fingers. Ideally, more structural stability in hinges could be achieved. The challenge then was to provide flexibility in building the playspace wall while not allowing individual bricks to move back and forth when children are using the space.

The first potential solution was the creation of multiple, fixed holes arrayed around the center hole with peg system (Figure 4-92). However, the difficulty of stacking the bricks together soon revealed itself in prototyping (Figure 4-94).

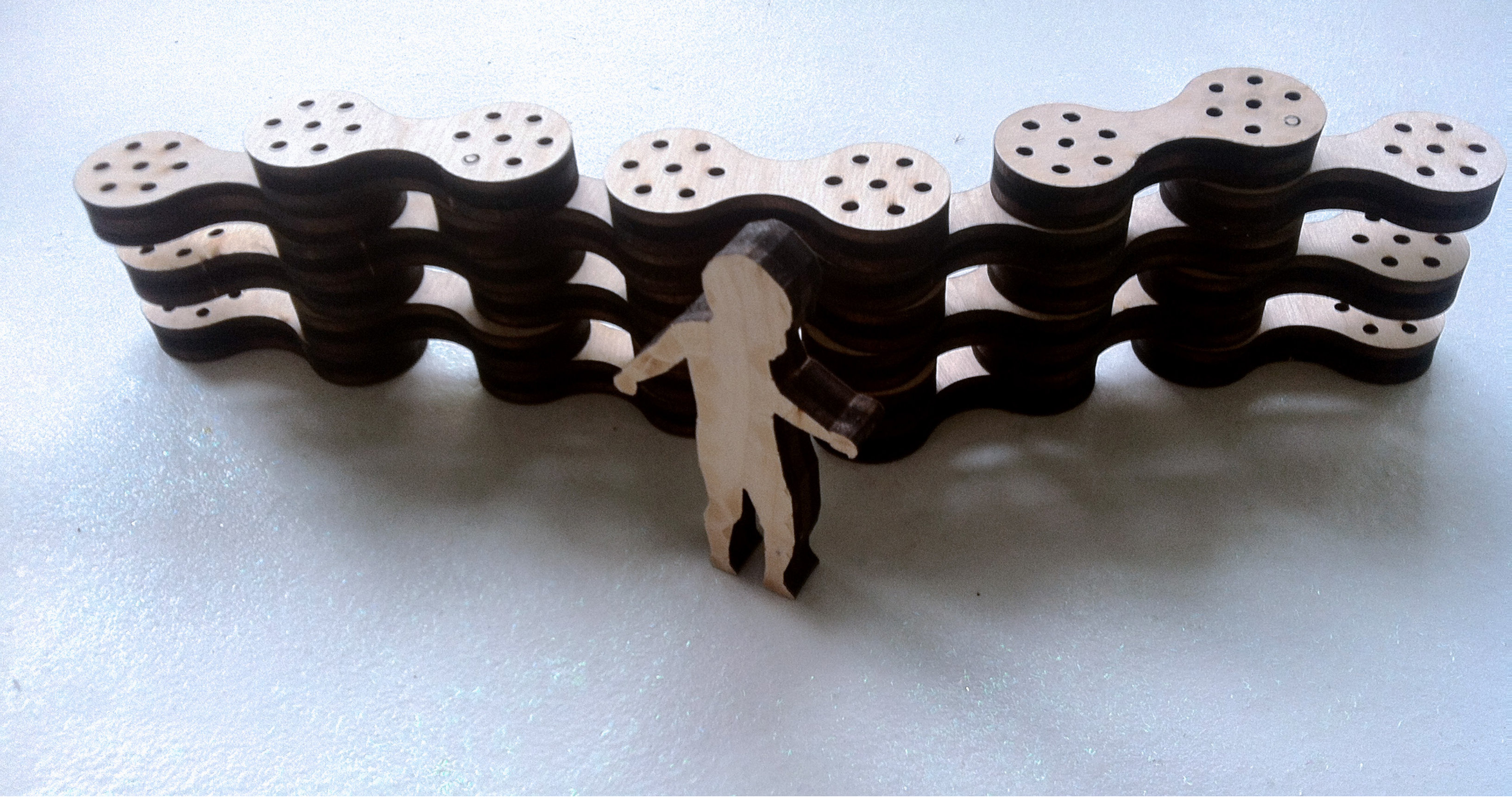


Figure 4-99: Miniature laser-cur playspace model exploration.

Testers frequently put pegs in wrong holes, which distorts the building process because offset bricks did not build a full structure. The pegs were both the same size so it was a common mistake to begin to stack bricks together in the wrong way. Additionally, the two peg system limited flexibility because one could not shift any bricks around once they were stacked on top of one another. This would require a lot of foresight and planning from users when building any form of the playspace.

To mitigate the issues of confusion and inflexibility, multiple holes of different sizes connected with poles of corresponding sizes were developed into the design. Holes of different sizes and poles of different thicknesses would allow for flexibility while the playspace is constructed and would reduce the issue of

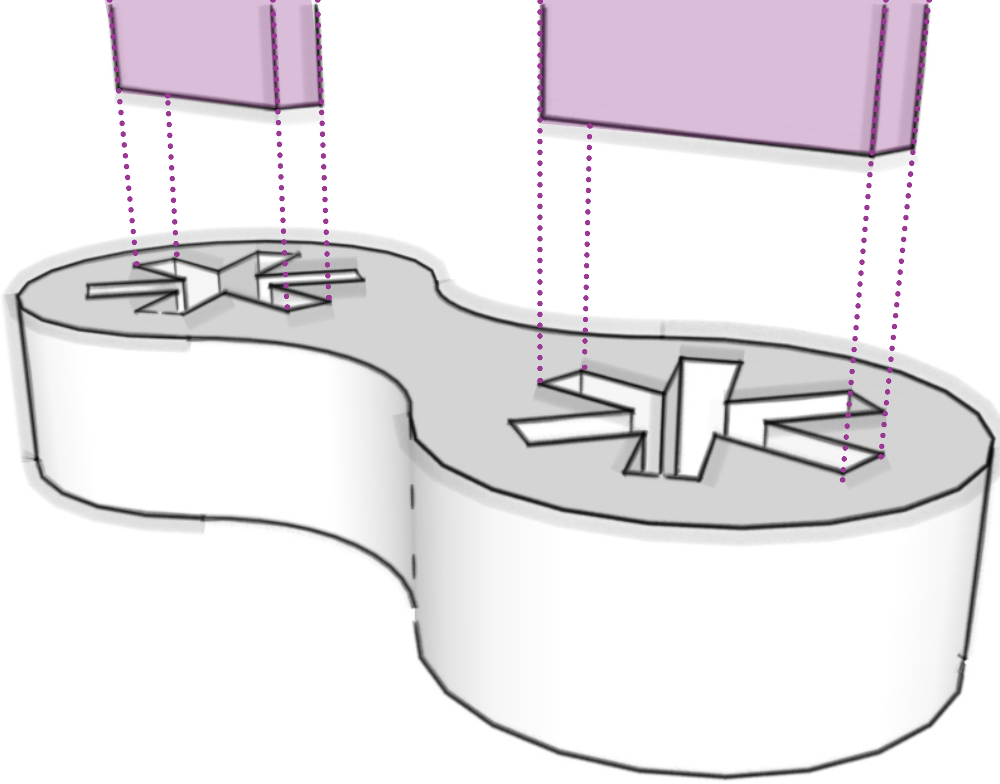


Figure 4-100: "Asterisk" hinge and flat locking mechanism.

shear by locking the bricks into place with the second set of poles (Figure 4-98). Unfortunately this exploration involved many parts and locking the bricks in place with a second set of poles might not be the most straightforward solution for users, caregivers, and village health workers putting the structures together.

The next step was to investigate how to simplify the locking mechanism with the two poles. An "asterisk" shaped hinge and flat "pole" was the response to too many poles (Figure 4-100). In this iteration, a single pole could lock the bricks together to prevent unwanted rotation. The flat surface provided a benefit in that ages and heights of the playspace could be expressed on the pole itself to help communicate the function of the wall to caregivers. However, the specific geometries of the pole and asterisk made lining up bricks difficult and negated the

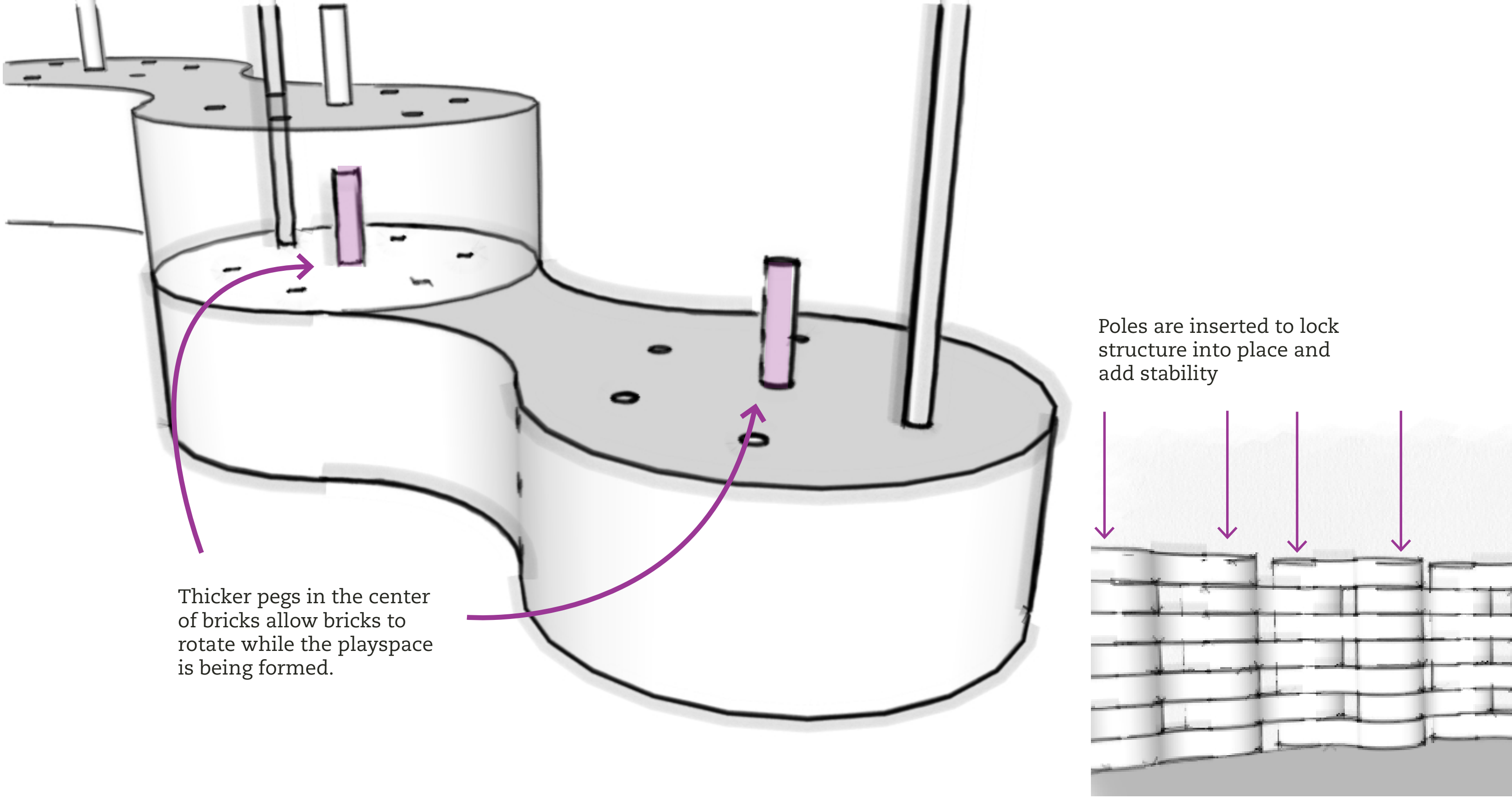


Figure 4-101: Two bricks with pegs, assembled incorrectly (offset).

goal of flexibility as the structure still could not be re-configured easily without taking the whole wall apart. As a working solution to all of the previous issues, a hybrid of the peg and pole solution was conceived. The middle pegs serve to line up the bricks while putting the pieces together. This peg makes building the structure simple but still allows for rotation and flexibility. After the bricks are stacked together in a configuration that is satisfactory to the user, thinner poles are added to lock bricks place at the end. Similar to the flat poles mentioned, these thin poles can also still delineate age and space heights and could be manufactured out of fiberglass, much like tent poles.

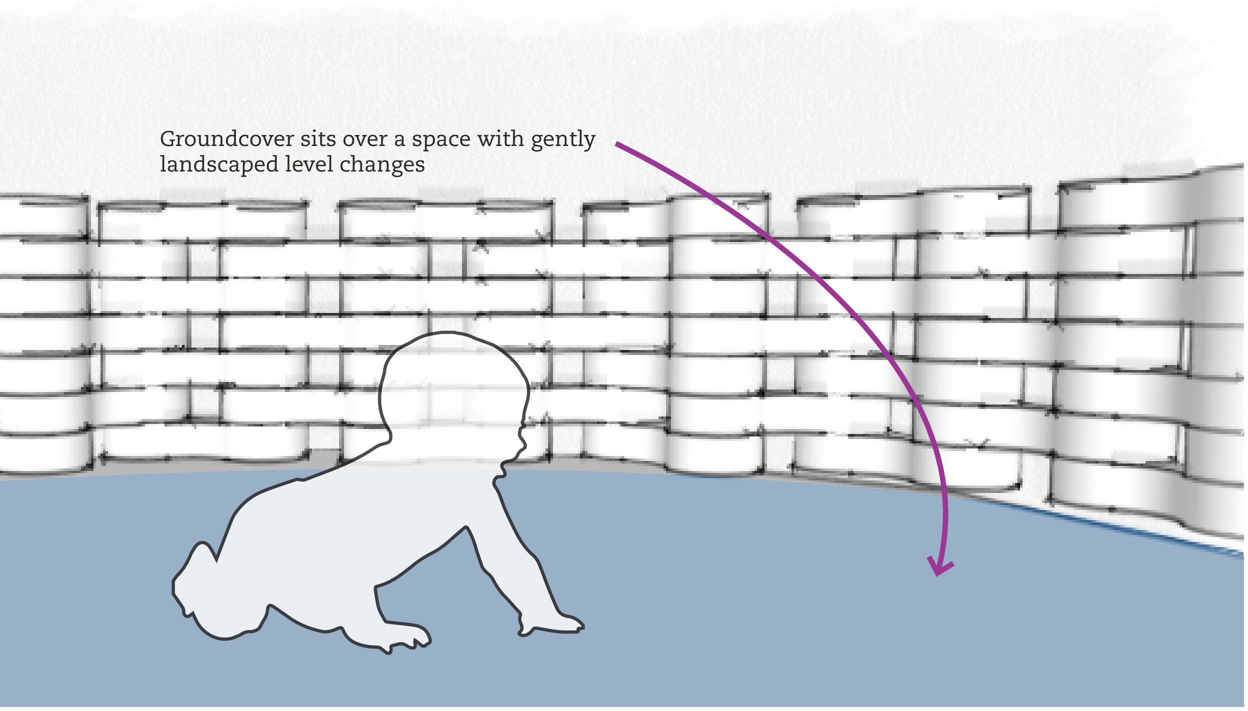


Figure 4-102: Infants' perspectives within the playspace, with groundcover.

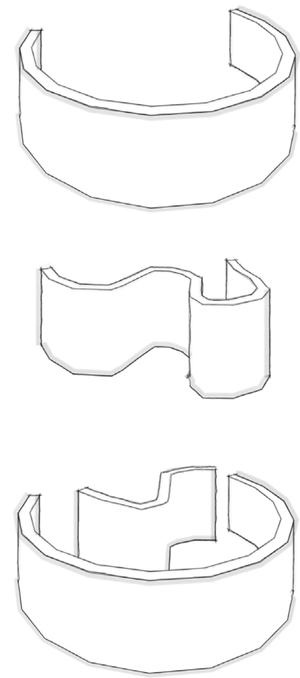


Figure 4-103: Playspace configuration option.

Materiality Considerations

Initial conversations about materiality began with an exploration of locally-sourced materials, whether natural or recycled. However, rural Zimbabwe has a significant lack of readily available materials to access or re-use. There are few consumer goods to recycle and widespread deforestation leaves little wood left to work with. Due to the size and scope of implementing thousands of protective playspaces, there were limitations in material availability, skilled craftspeople, and time. This, coupled with many performance requirements made plastic as the material of choice for cost and durability. The playspaces need to withstand termites, weather systems, transport, storage, and growth. The playspaces also can not harbor microbes and they must be easy to clean and safe for children to mouth.

The choice of plastic as a viable material called preconceived ideas

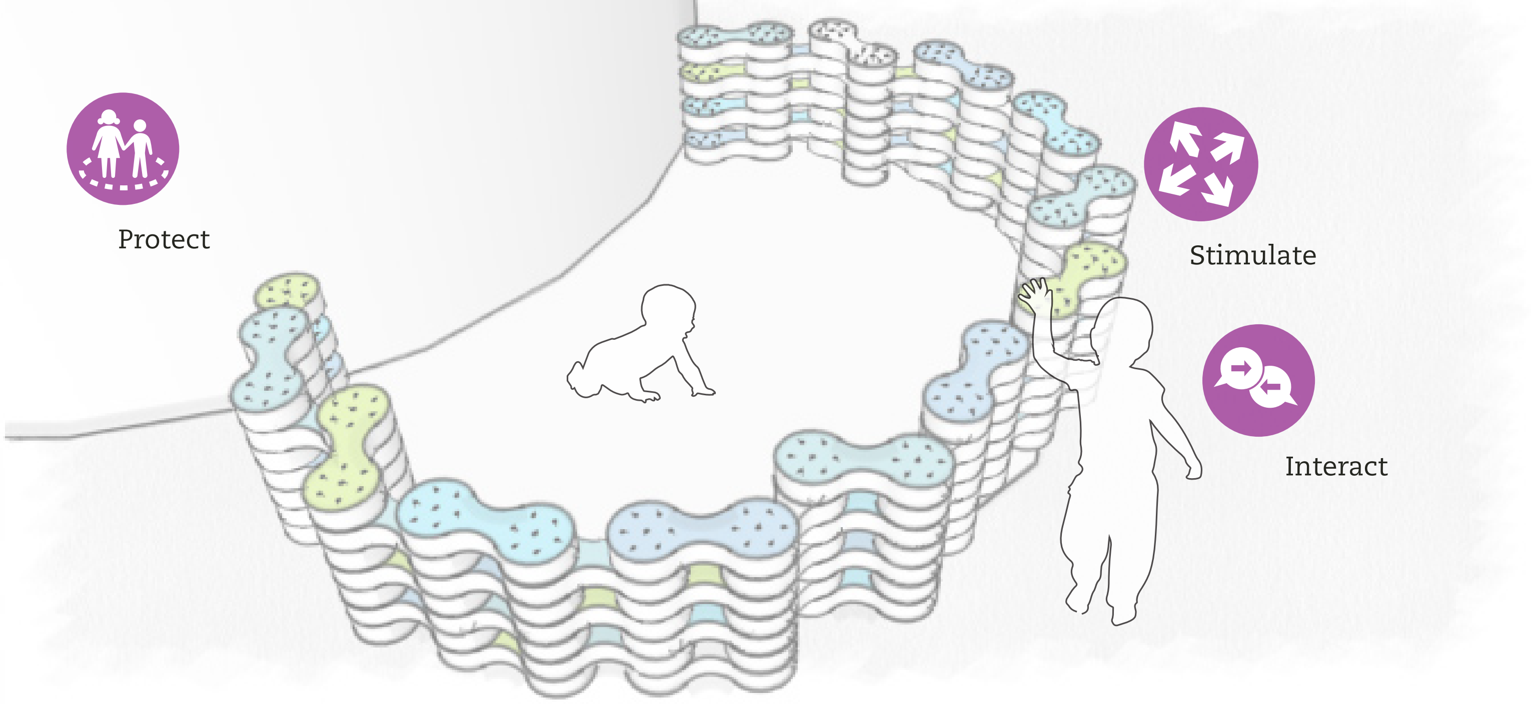


Figure 4-104: Constructed playspace attached to compound structure.

of “good” or “bad” materials into question. Caregivers and mothers from Zimbabwe specifically cited plastic as their material of choice for durability and were skeptical that natural materials could withstand years of infant and toddler use. Mothers outlined the life-cycle of a playspace as something that would be passed around the community as needed by mothers rather than re-purposed for other uses so natural materials were undesirable. From a manufacturing standpoint, injection molded plastics offer flexibility in the number of bricks produced, colors, textures, weight, and structural properties.

In contrast, the ground-cover allows for a lower-fidelity solution. While anti-microbial ground covers in conjunction with bricks would be ideal, they were ultimately too expensive to produce and distribute. Instead, recycling textiles or polypropylene corn sacks offer a suitable alternative.

Section Two

Assessment

Introduction

Experts on various subjects were consulted throughout the design development process of the project, but in the final stages of the design a nutrition researcher with knowledge of maternal and child nutrition, social and behavior change interventions, infant feeding, and a background in Public Health was consulted to review the efficacy of the design, the design guidelines, and how the two areas of the project relate. This way insights from beyond the research team can be integrated into further development and discourse.

Comment on Design Guideline 1:

Provide a nurturing and sensory-rich environment for children's earliest interactions with the physical world.

"This guideline is needed. [But] even though I think I understand what is meant by nurturing in this guideline, when I read the guideline, it was hard for me to think of a physical environment being nurturing. I think it could be encouraging and engaging, but when I think of nurturing I think of it more as it relates to Design Guideline 3 rather than the sensory-rich environment described in #1."

Comment on Design Guideline 2:

Encourage children to learn to move and to delight in practicing new physical skills.

"This is important even before walking and crawling, including rolling over and pulling up."

Comment on Design Guideline 3:

Maximize children's physical and emotional contact with adults, caregivers, and social peers.

"I think this is the most important of all the guidelines.

It might be worth including that it would allow and encourage caregiver-child interaction (not only sibling interaction)."

Comment on Design Guideline 4:

Facilitate caregiver tasks and to encourage the use of the protective play space.

"From what I know, this is a desirable and necessary guideline."

Does the playscape design provide a nurturing and sensory-rich environment for children?

1 2 3 4 5

No, not at all — Yes, very much

Does the playscape design provide a nurturing and sensory-rich environment for children?

1 2 3 4 5

No, not at all — Yes, very much

Does the playscape design provide a nurturing and sensory-rich environment for children?

1 2 3 4 5

No, not at all — Yes, very much

Does the playscape design provide a nurturing and sensory-rich environment for children?

1 2 3 4 5

No, not at all — Yes, very much

Comment on the design overall, in regards to the guidelines or your own assessment.

"For guideline 3, would older children be encouraged to be inside the playspace with the younger child or would the idea be that the child is always alone in it? It would be nice if others could be inside with the baby. Instead of contact, I would use the word interaction.

For guideline 4, are there other safety issues that caregivers in Zimbabwe are concerned about? As a parent in the US, I would be very concerned about young, exploring babies putting small things in their mouths and choking and would be happy to have a space free of small items. I wonder if there are other safety characteristics that are appealing to caregivers beyond the chicken and e coli that we are worried about (since maybe the choking is not a huge concern). But I think it is important for the caregivers to see value in the playspace beyond the hygiene. From studies related to other hygiene and health products (cookstoves, latrines, water filters), it is rarely the health benefits that motivate people to use them and so I would highlight those other characteristics that are appealing as well, like making it easier for caregivers to do all of the things they need to do (which you have).

This is not really that related, but one thing that I thought was interesting is that this could be a place for young children while their mothers are cooking. Indoor air pollution from cooking over biomass stoves contributes to health problems in children. A study in South Africa encouraged mothers to leave their kids out of the kitchen to reduce their exposure to the smoke. The mothers had a hard time doing it because they did not have a place to put the kids and so the kids would cry and the moms would bring them back in (though this was the easiest of all the recommended behaviors to adopt). This could potentially be a way to reduce kids exposure to smoke too.

I also think the lego design is great for older kids to be involved in the construction of the space and also nice that it can work on the differing terrains."

Comment on any guidelines you would include in addition to the four presented.

"I wonder if safety should be its own guideline or if it is covered sufficiently in Guideline 4. It would depend on what characteristics were most important to the potential users, but it would be a key feature for me as a parent."

Guideline 01

Provide a nurturing and sensory-rich environment for children's earliest interactions with the physical world.

The playspace provides active and socially relevant play, which is required for healthy brain growth.

Provide an environment filled with sensory experiences such as smells, sounds, colors, light, and varied tactile experiences.

Guideline 02

Encourage children to learn to move and to delight in practicing new physical skills.

Infants and toddlers need opportunities to roam freely to satisfy their desire to perfect balancing and walking skills.

Playspace size should align with current practices.

Provide an engaging space that encourages motor exploration.

Deriving a space from design guidelines

The final rounds of design iteration honed in on the design guidelines developed from extensive research from the many facets of the playspace project. In the first guideline, the goal was to provide a nurturing and sensory-rich environment for children's earliest interactions with the physical world. The playspace as it has been designed seeks to provide active and socially relevant play required for healthy brain growth by creating a space that engages multiple senses. Infants and toddlers will be able to explore form and texture in the shape of the bricks while watching shadows play in the spaces between the hinged and flexible structure. The vertical wall provides a dynamic surface for personalization

Guideline 03

Maximize children's physical and emotional contact with adults, caregivers, and social peers.

Cultural play styles must be identified and catered to in a sensitive and acceptable way.

The space should also be inviting to older siblings.

The design of the space should reflect the homestead and cultural values within the community.

Guideline 04

Facilitate caregiver tasks and to encourage the use of the protective play space

The space should accomodate variable terrains.

The space should be easy to maintain, keep clean, understand, put together, and take apart.

The design should prohibit child-chicken and child-E.coli interactions while following applicable safety guidelines.

and promotes fine motor development through surface exploration. Additional opportunities for stimulation exist in color variation of the blocks or groundcover, adding textural patterns to the block faces, or suggesting that caregivers provide natural materials for infants to explore. The vertical wall can also be configured in a few different ways to allow children to have an inside/outside experience in a curving or undulating structure.

Guideline two involves encouraging children to learn to move and to delight in practicing new physical skills. The current iteration of the playspace does this by providing surfaces at various levels for children to pull themselves up on, stick objects in, cruise, and learn to walk on. The size of the bricks was developed to allow small hands and feet ample space to support themselves on and the curvilinear shape of the bricks provides challenges as infants and toddlers navigate their way around the structure. The shape and size of gaps allow for gross motor play at all ages from a spectrum of smaller children learning to walk to older children climbing and exploring in more advanced ways.

By developing a playspace with older children and peers in mind, the design seeks to fulfill the requirements of design guideline three by maximizing children's physical and emotional contact with adults, caregivers, and social peers. Infants and toddlers have visual access to their caregivers through the slatted nature of the playspace and its suggested location next to the kitchen of the homestead for increased parent contact. Furthermore, providing a play area that is inviting and accessible by children of all ages to encourage multiple peer interactions is achieved by the stability and form of the playspace. Interactions are therefore encouraged within and around the space. The modular pieces themselves could also be made into a simple educational tool for school-aged children. For example, the angles of holes could be used to communicate basic geometry concepts as the children help their parents build the playspace (Figure 4-105).

The fourth guideline requires that the playspace facilitate caregiver tasks and to encourage the use of the protective play space. The space is modular and flexible to accommodate variable terrains. The space's modular bricks also allow

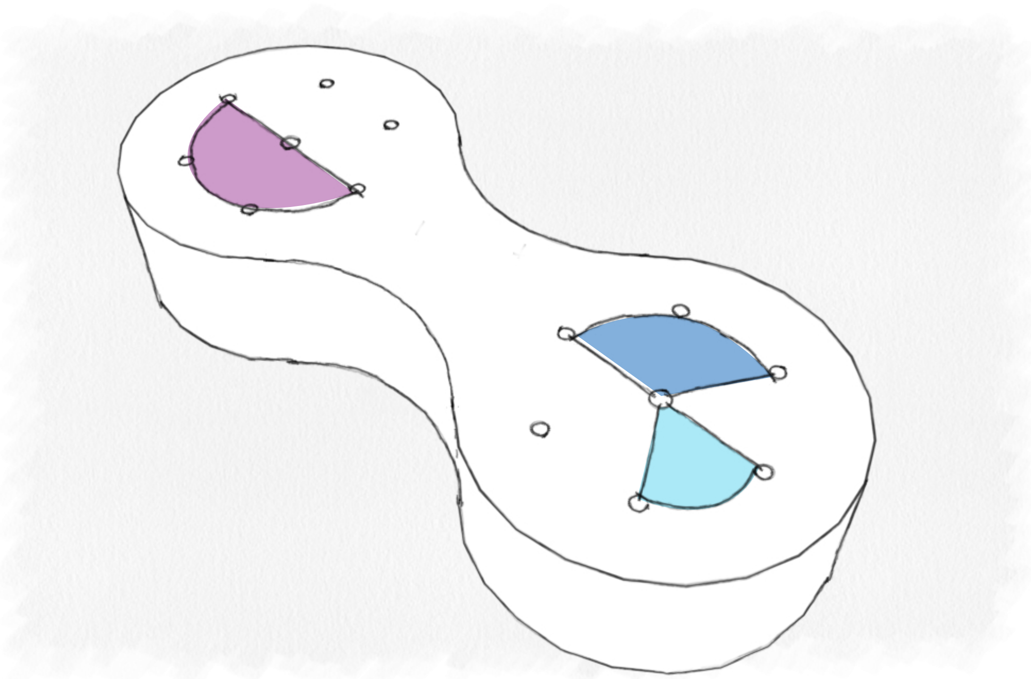


Figure 4-105: Possible geometry and educational block iteration.

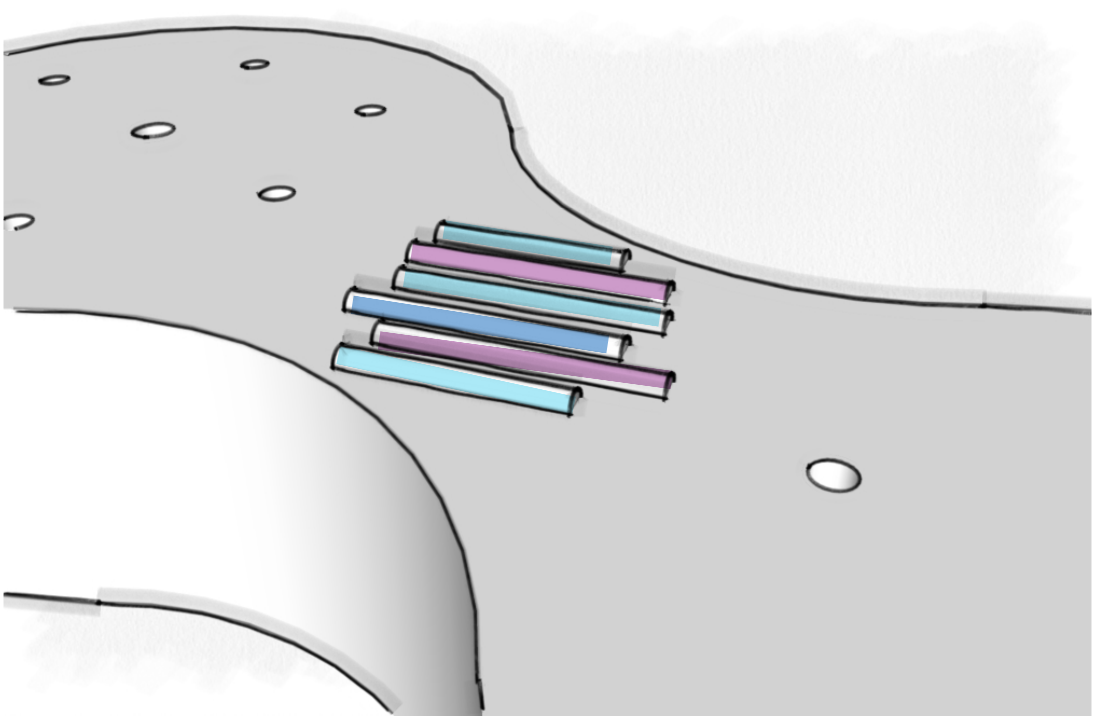


Figure 4-106: Possible tactile and non-slip surfaces on bricks.

parts of it to be replaced if needed and seek to streamline the process of putting the playspace together or taking it apart. The material suggestion of plastic keeps the weight of each brick down and makes the space durable against termites, weather patterns, and everyday wear and tear. The space follows applicable safety guidelines. For example, the size of the gaps also is developed according to childcare safety guidelines to protect against entrapment of head. The space's proximity to the kitchen (or similar structure) on the homestead compound strategically takes advantage of existing shade to offer protection from the sun and other elements. Additionally, the reconfigurable nature of the playspace means it can be located under nearby trees and around large rocks for more shade, natural light play, and additional motor and cognitive development (Figure 4-107).

The design ultimately seeks to prohibit young children's interactions with contaminated soil in an effort to mitigate the effects of environmental enteropathy on malnutrition, stunting, and anemia. To achieve this, a ground barrier protects from existing contamination, facilitates clean-up by caregivers, can be transported, and provides a clean eating surface. The vertical barrier creates a separation between infants and wandering livestock, contaminated feet, and walking poultry. While the playspace has not been tested specifically to prohibit all chickens from entering, the vertical barrier will at the very least make the space for caregivers to keep clean smaller and easier to manage. Some suggested complementary chicken husbandry practices include the provision of a water dish away from infant play area and potentially providing a safe night roosting space.

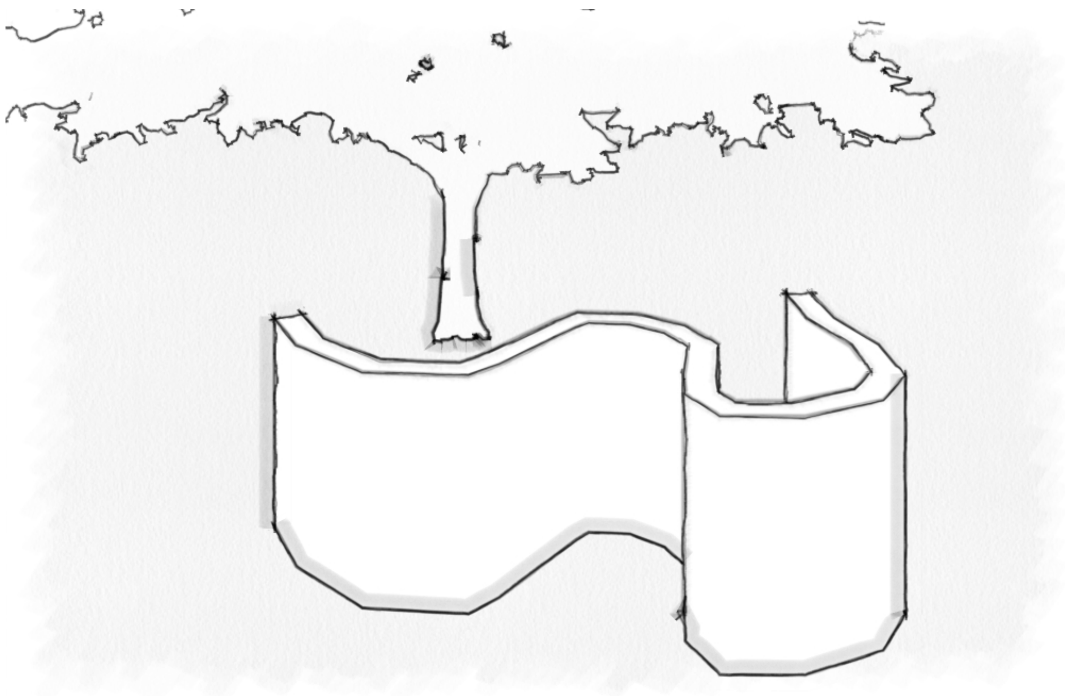


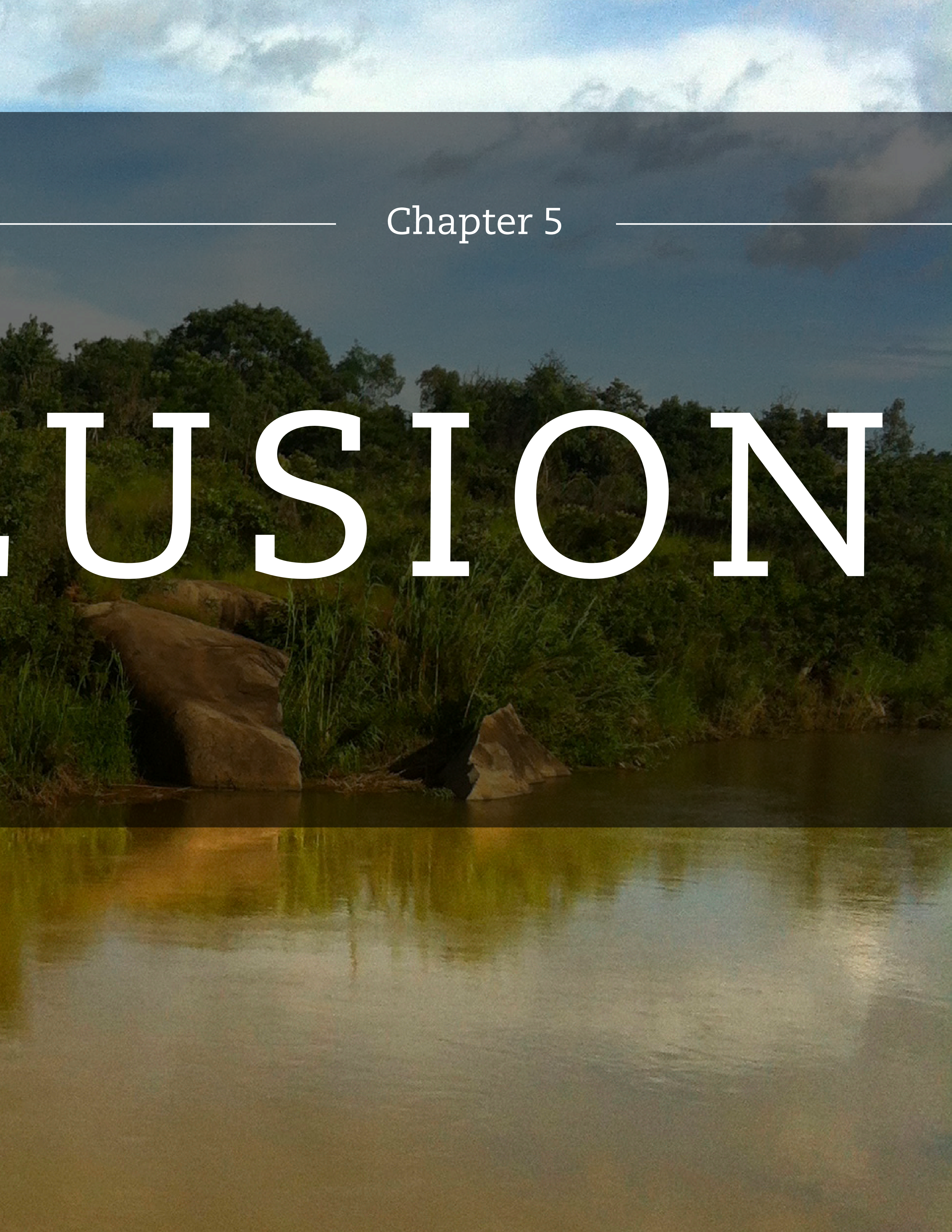
Figure 4-107: Additional homestead locations.

Finally, the vertical barrier provides a visual reminder of the importance of providing a protected playspace for developing babies. In this way, the playspace seeks to aid in behavior-change on an educational level while making the task of baby hygiene and sanitation more accessible to caregivers in rural Zimbabwe.


CONCL

Chapter 5

LUSION



Section One

Design Reflection

Insights on the Process

RIGOR AND RESEARCH THAT INFORMED THE PROJECT

The rigor that informed the project was specifically social and evidence-based design. Research was chosen in a holistic way that matched the goals and expectations of the team on the trial. As the design is intended for children, child development and its many theories and avenues were explored in addition to issues of nutrition and sanitation. The researchers chose to focus on neurobiological, bioecological, and socio-cultural perspectives so as to have studies focusing on brain, body, and context. It was important that the research was found from the source itself rather than child-care design guidelines because many of the existing design guidelines were based on early childhood development literature by Piaget that was already decades old. This highlights the need for increased awareness of more accurate child development theories and the gap currently between design and user need is frustrating for current designers to bridge. Multiple theories of child development were selected because evidence-based design is rooted not in select data points but in a holistic understanding of the subject matter.

All studies on early-childhood development are based on Western cultural context, so short-term ethnographic research was conducted to fit snapshots of rural Zimbabwe to a composite image of what life is like in order to compare and contrast with Western literature. Developing an ethnographic understanding was critical for design development because the team was designing for population half a world away. A number of pilot studies on baby feeding practices, play-yard opinions, and informal interviews made the local partner organization Zvitambo a critical resource. As discussed previously, field interviews highlighted the gap between users and researchers' conceptions of what users want or need. The process of conducting field interviews also cast the challenges of cross-cultural communication in stark relief. Due to the political climate at the time, the tour to rural areas of Zimbabwe was conducted by government ministries. Speaking with experts from the Zimbabwean Ministry of Health and Child Welfare was especially informative but it was impossible to know if the families selected by the government reflected the full spectrum of the rural experience.

There was naiveté on the designer's part about just how large a user-researcher gap could be. Current human-centered design practices put glossy sheen over reality of gathering information, especially when using a translator to speak in Shona. The designer intended to find out more about the daily life in rural Zimbabwe, how infants play and interact with their mothers, and very little about the idea of play-yards. However in an effort to be helpful and communicative to the caregivers being interviewed, the translator instead started with an explanation about the scope of the study and the connections between current child-rearing practices and stunting. Understandably, interviews started from a defensive stance from mothers and it was difficult to gather good information on general activities when everything had been placed under the light of malnourishment, sanitation, and hygiene. This additionally made observing and taking notes somewhat strained. Maintaining a delicate balance between a site observation and respect for the site as the user's home was not a small challenge. While sketching and observing was helpful to see the structures and relationships between objects in the homestead, site observation methods are clinical and incongruous with the intimate nature of visiting someone's home. How does one balance efficacy of research and ethnography methods with the intuition that the researcher and designer is intruding on someone's life? Ethnography called into question the best ways to gather cultural data. There seemed to be a kind of arrogance in the assumption that Western observational methods were the ideal. Why should designers use research with a Western cultural bias in an entirely different culture? The experience brought up the issue of silos between disciplines, cultures, and people when designing with a human focus.

It should be noted that the silos between disciplines were not here for lack of trying. Due to the unique approach to a research and design solution, the team was found wanting in subject matter experts. Experienced researchers in nutrition, microbiology, or sanitation knew very little about child development. There was a serious lack of experience in any idea of protective playspaces so the team needed to piece together expertise to form a more complete picture of the project. Experts in chicken husbandry, nutrition, microbiology, design, child development, and psychology contributed to the myriad of questions that came up throughout the process. Regardless, even subject matter expert opinions differed significantly from user experience significantly, emphasizing the need for user involvement critical. While there was effort to involve end users as much as possible, more comprehensive user involvement is necessary.

Socially-motivated, evidence-based design is ambitious with any project. It is a continuously evolving process that presents challenges and more questions at every turn. There is no “good” point to stop when researching because there are always different directions and conflicting pieces of research to contend with. Designers must be mindful in which parts of the research on which to focus the guidelines. It is a process that requires the designer to be humble, readily admitting mistakes and backtracking. Design interventions and evidence-based design are not purely academic pursuit: there are empirical studies but also real people involved. This process emphasized the necessity of drawing from the user’s perspective, referring back to it, and holding it as evidence alongside published research.

ADDITIONAL CONSIDERATIONS

Cost in a developing economy remains a problem that will continue to be developed in future iterations as the design goes through a manufacturing process. With a goal to balance affordability and security, the project seeks to cost an average of $50 per playspace. This cost estimate is competitive with smaller play yard products available in America (priced at anywhere from $100 - $150).

However, this prices makes the playspace a significant investment even for the best-off members of the target communities. Because many families are sustenance farmers, investing $50 for a playspace would be unthinkable. More research is needed to determine an appropriate economic mechanism to promote protective playspaces or an alternative, cheaper design if the biological efficacy of the design solution is confirmed. Through cooperatives or micro-credit initiatives, communities may be able to buy materials at lower cost and with some level of financing or subsidy. The playspace could also be purchased as community-owned playspaces, used as educational tools in crèches, or re-used as building materials for animals, gardens, or low-wall construction. Within the rural Zimbabwean context, the pieces of the playspace could see many unique and extended uses along the course of its lifetime that differ greatly from the expected landfill outcome that is so prevalent in America.

Further research into manufacturing processes is required to determine the precise cost of each playspace. The current iteration of the playspace is developing with the intention of injection blow-molding pieces to then break down the cost by mold, machining and tooling, piece, and playspace cost overall. Plastics are inexpensive, lightweight and durable materials, which can readily be molded into the playspace product (Andrady & Neal 2009). With regards to the playspace's carbon footprint, lightweight plastics take less energy to produce and transport than many other materials. The playspace is intended for long-term and multiple uses rather than single-use, disposable plastic items. Ideally the product could be manufactured completely in Zimbabwe to save on the energy and cost of shipping as well as partner with the local manufacturing economy. This way, wealthier urban families could also become a key demographic in the protective playspace to offset the costs of providing the spaces to rural communities.

The cost per playspace aside, it is important to note that addressing malnutrition is likely to yield high economic returns and speed up poverty reduction . In 2004, the Copenhagen Consensus, a panel of economists ranked programs to address child stunting among those with the highest rates of economic returns (Lomborg, 2004). The economic benefits from improved nutrition come from reduced infant and child mortality and from reduced costs of health care. Economic benefits also include productivity gains from reduced stunting due to increased schooling and healthy early childhood development. As noted previously, malnutrition affects the timing of school entry, the number of years completed, and the learning that takes place while in school - all of which, when improved, could lead to increased lifetime earnings. When controlling for education, individuals with higher cognitive abilities earn more than their less cognitively capable peers (Behrman et al., 2004).

THE VALUE

Having a tangible object for the community to interact with brings visibility to needs of infants in the first 1000 days of life. The playspace highlights the need for a protected space and underscores the need for nutrition while linking a child’s play environment with microbes. The use of a physical playspace also improves the research experience. Most obviously, it allows for direct behavior observation for researchers. Another research benefit to a protected playspace (or other physical and environmental interventions) is helping researchers conceptualize the way such an intervention can impact lives across disciplines. Physical interventions in addition to behavior change interventions adds value to the project as a whole.

Studies have shown that children with stunting lag behind peers throughout the rest of childhood and into adulthood both physically and mentally. By combating stunting early in life, this project can improve the lifetime productivity and economic outlook for individuals with high risk of stunting in childhood.

This project signified a paradigm shift from looking at nutrition and WASH interventions separately to combining them and adding a design component. From the perspective of the designer, there was an exciting paradigm shift towards designing as part of a research trial, something that is very uncommon in social sector design.

Section Two

Bibliography

Adolph, Karen E, Vereijken, Beatrix, & Shrout, Patrick E. (2003). What changes in infant walking and why. *Child Development, 74*(2), 475-497.
Andrady, Anthony L, & Neal, Mike A. (2009). Applications and societal benefits of plastics. *Philosophical Transactions of the Royal Society B: Biological Sciences, 364*(1526), 1977-1984.
Beckett, Celia, Maughan, Barbara, Rutter, Michael, Castle, Jenny, Colvert, Emma, Groothues, Christine, . . . Sonuga - Barke, Edmund JS. (2006). Do the effects of early severe deprivation on cognition persist into early adolescence? Findings from the English and Romanian adoptees study. *Child Development, 77*(3), 696-711.
Berger, SE., Theuring, C., & Adolph, KE. (2006). How and when infants learn to climb stairs. *Infant Behavior and Development, 30*(1), 36-49.
Berk, Laura E. (2012). *Infants and children: Prenatal through middle childhood*. Boston: Pearson.
Berk, Laura E., Mann, Trisha D., & Ogan, Amy T. (2006). Make-believe play: Wellspring for development of self-regulation. *Play= learning: How play motivates and enhances children's cognitive and social-emotional growth*, 74-100.
Bhat, A, Heathcock, J, & Galloway, JC. (2005). Toy-oriented changes in hand and joint kinematics during the emergence of purposeful reaching. *Infant Behavior and Development, 28*(4), 445-465.
Bodrova, Elena, & Leong, Deborah J. (2003). Chopsticks and Counting Chips: Do Play and Foundational Skills Need To Compete for the Teacher's Attention in an Early Childhood Classroom? *Young Children, 58*(3), 10-17.
Bodrova, Elena, & Leong, Deborah J. (2007). Play and early literacy: A vygotskian approach. *Play and literacy in early childhood: Research from multiple perspectives*, 185-200.
Bourgeois, Kristine S, Khawar, Alexa W, Neal, S Ashley, & Lockman, Jeffrey J. (2005). Infant manual exploration of objects, surfaces, and their interrelations. *Infancy, 8*(3), 233-252.
Bradley, Robert H, & Corwyn, Robert F. (2002). Socioeconomic status and. *Annual review of psychology, 53*(1), 371-399.
Bransford, John D, Brown, Ann L, & Cocking, Rodney R. (2000). *How people learn*: National Academy Press Washington, DC.
Bronfenbrenner, Urie. (1979). Contexts of child rearing: Problems and prospects. *American psychologist, 34*(10), 844-850.
Bronfenbrenner, Urie, & Ceci, Stephen J. (1994). Nature-nuture reconceptualized in developmental perspective: A bioecological model. *Psychological Review, 101*(4), 568-586.
Bronfenbrenner, Urie, & Evans, Gary W. (2000). Developmental science in the 21st century: Emerging questions, theoretical models, research designs and empirical findings. *Social development, 9*(1), 115-125.

Casakin, H., & Kreitler, S. (2005). The nature of creativity in design. *Studying Designers, 5*, 87-100.
de Campos, Ana Carolina, Rocha, Nelci Adriana Cicuto Ferreira, & Savelsbergh, Geert JP. (2010). Development of reaching and grasping skills in infants with Down syndrome. *Research in Developmental Disabilities, 31*(1), 70-80.
Dewey, K. G., & Adu-Afarwuah, S. (2008). Systematic review of the efficacy and effectiveness of complementary feeding interventions in developing countries. *Maternal & Child Nutrition*, *4*(s1), 24-85.
Engle, Patrice L, Black, Maureen M, Behrman, Jere R, Cabral de Mello, Meena, Gertler, Paul J, Kapiriri, Lydia, . . . Young, Mary Eming. (2007). Strategies to avoid the loss of developmental potential in more than 200 million children in the developing world. *The Lancet, 369*(9557), 229-242.
Engle, Patrice L, Fernald, Lia CH, Alderman, Harold, Behrman, Jere, O'Gara, Chloe, Yousafzai, Aisha, . . . Ertem, Ilgi. (2011). Strategies for reducing inequalities and improving developmental outcomes for young children in low-income and middle-income countries. *The Lancet, 378*(9799), 1339-1353.
Evans, Gary W. (2004). The environment of childhood poverty. *American psychologist, 59*(2), 77.
Fenson, Larry, Kagan, Jerome, Kearsley, Richard B, & Zelazo, Philip R. (1976). The developmental progression of manipulative play in the first two years. *Child Development*, 232-236.
Fomon, Samuel J, & Nelson, Steven E. (2002). Body Composition of the Male and Female Reference Infants 1. *Annual review of nutrition, 22*(1), 1-17.
Garrett, M., McElroy, A. M., & Staines, A. (2002). Locomotor milestones and babywalkers: cross sectional study. BMJ, 324(7352), 1494.
Golden, Mark, Birns, Beverly, Bridger, Wagner, & Moss, Abigail. (1971). Social-class differentiation in cognitive development among black preschool children. *Child Development*, 37-45.
Gore, Al, & Gore, Tipper. (2003). *Joined at the heart: The transformation of the American family*: Macmillan.
Grantham-McGregor, Sally, Cheung, Yin Bun, Cueto, Santiago, Glewwe, Paul, Richter, Linda, & Strupp, Barbara. (2007). Developmental potential in the first 5 years for children in developing countries. *The Lancet, 369* (9555), 60-70.
Greenough, William T, & Black, JE. (1992). Induction of brain structure by experience: Substrates for cognitive development. In M. N. Gunnar, CA (Ed.), *Minnesota symposia on child psychology* (pp. 155-200). Hillsdale, NJ: Erlbaum.
Haight, Wendy L, & Black, James E. (2001). A comparative approach to play: Cross-species and cross-cultural perspectives of play in development.

Human Development, 44(4), 228-234.
Haight, Wendy L, Wang, Xiao-lei, Han-tih Fung, Heidi, Williams, Kimberly, & Mintz, Judith. (1999). Universal, developmental, and variable aspects of young children's play. *Child Development, 70*(6), 1477-1488.
Hall, Edward Twitchell. (1969). *The hidden dimension*: Anchor Books New York.
Harvey, Steven A, Winch, Peter J, Leontsini, Elli, Torres Gayoso, Cecilia, López Romero, Sonia, Gilman, Robert H, & Oberhelman, Richard A. (2003). Domestic poultry-raising practices in a Peruvian shantytown: implications for control of *Campylobacter jejuni*-associated diarrhea. *Acta tropica, 86*(1), 41-54.
Huttenlocher, Janellen, Vasilyeva, Marina, Cymerman, Elina, & Levine, Susan. (2002). Language input and child syntax. *Cognitive Psychology, 45*(3), 337-374.
Jennings, Harmon, Robert, Morgan, George A, Gaiter, Juarlyn L, & Yarrow, Leon J. (1979). Exploratory play as an index of mastery motivation: Relationships to persistence, cognitive functioning, and environmental measures. *Developmental Psychology, 15*(4), 386-394.
Jenvey, VB., & Jenvey, HL. (2002). Criteria used to categorize children's play: Preliminary findings. *Social Behavior and Personality* (30), 733-740.
Johnson. (2005). Development neuroscience psychophysiology and genetics. In M. H. Bornstein & M. E. Lamb (Eds.), *Developmental Science: An advanced textbook* (Vol. 5th edition pp. 187-222). Mahwah, NJ: Erlbaum.
Johnson, James Ewald, Christie, James F, & Wardle, Francis. (2005). *Play, Development, and Early Education*: Allyn & Bacon.
Kaiser, Barbara, & Rasminsky, Judy Sklar. (2003). Opening the Culture Door. *Young Children, 58*(4), 53-56.
Karasik, L. B., Adolph, K. E., Tamis-LeMonda, C. S., & Bornstein, M. H. (2010). WEIRD walking: Cross-cultural research on motor development. The Behavioral and brain sciences, 33(2-3), 95.
Knickmeyer, Rebecca C, Gouttard, Sylvain, Kang, Chaeryon, Evans, Dianne, Wilber, Kathy, Smith, J Keith, . . . Gilmore, John H. (2008). A structural MRI study of human brain development from birth to 2 years. *The Journal of Neuroscience, 28*(47), 12176-12182.
Konner, Melvin. (1977). Infancy among the Kalahari desert San. *Culture and infancy: Variations in the human experience*, 287-328.
Kreppner, Jana, Kumsta, Robert, Rutter, Michael, Beckett, Celia, Castle, Jennifer, Stevens, Suzanne, & Sonuga ‐ Barke, Edmund J. (2010). IV. Developmental course of deprivation ‐ specific psychological patterns: early manifestations, persistence to age 15, and clinical features. *Monographs of the Society for Research in Child Development, 75*(1), 79-101.
Laplante, David P, Zelazo, Philip R, Brunet, Alain, & King, Suzanne. (2007). Functional play at 2 years of age: Effects of prenatal maternal stress. *Infancy,*

12(1), 69-93.
Lerner, R. M., Jacobs, F., & Wertlieb, D. (Eds.). (2005). Applied Developmental science: An advanced textbook. Sage.
Levitsky, David A, & Barnes, Richard H. (1972). Nutritional and environmental interactions in the behavioral development of the rat: long-term effects. *Science, 176*(4030), 68-71.
Lomborg, Bjørn. (2004). *Global crises, global solutions: Costs and benefits*. Cambridge University Press.
Lozoff, B., & Georgieff, M. K. (2006, September). Iron deficiency and brain development. In *Seminars in pediatric neurology* (Vol. 13, No. 3, pp. 158-165). WB Saunders.
Lozoff, Betsy, Jimenez, Elias, & Smith, Julia B. (2006). Double burden of iron deficiency in infancy and low socioeconomic status: a longitudinal analysis of cognitive test scores to age 19 years. *Archives of Pediatrics & Adolescent Medicine, 160*(11), 1108.
Lozoff, Betsy, Klein, Nancy K, Nelson, Edward C, McClish, Donna K, Manuel, Martin, & Chacon, Maria Elena. (1998). Behavior of Infants with Iron‐Deficiency Anemia. *Child Development, 69*(1), 24-36.
Marquis, Grace S, Ventura, Gladys, Gilman, ROBERT H, Porras, E, Miranda, ELBA, Carbajal, Luz, & Pentafiel, MARTA. (1990). Fecal contamination of shanty town toddlers in households with non-corralled poultry, Lima, Peru. *American Journal of Public Health, 80*(2), 146-149.
Martorell, Reynaldo, Melgar, Paul, Maluccio, John A, Stein, Aryeh D, & Rivera, Juan A. (2010). The nutrition intervention improved adult human capital and economic productivity. *The Journal of nutrition, 140*(2), 411-414.
. The Millenium Development Goals Report 2012. (2012). In T. Wall (Ed.), (pp. 72): United Nations.
Moore, Keith L, & Persaud, Trivedi Vidhya Nandan. (2008). *Embriologia clínica*: Elsevier.
Ngure, Francis. (2012). Environmental Hygiene, Food Safety And Growth In Less Than Five Year Old Children In Zimbabwe And Ethiopia.
Nyota, Shumirai, & Mapara, Jacob. (2008). Shona traditional children's games and play: songs as indigenous ways of knowing. *The Journal of Pan African Studies, 2*(4), 189-202.
O'Connor, Thomas G, Rutter, Michael, Beckett, Celia, Keaveney, Lisa, & Kreppner, Jana M. (2000). The Effects of Global Severe Privation on Cognitive Competence: Extension and Longitudinal Follow-up. *Child Development, 71*(2), 376-390.
Oakland, Thomas, Mpofu, Elias, & Sulkowski, Michael. (2006). Temperament styles of Zimbabwe and US children. *Canadian Journal of School Psychology, 21*(1-2), 139-153.
OWP/P Cannon Design, VS Furniture, & Design, Bruce Mau. (2010). *The Third*

Teacher: 79 Ways You Can Use Design to Transform Teaching & Learning. New York: Abrams.
Piaget, Jean. (1962). *Play, dreams and imitation* (Vol. 24). New York: Norton.
Piek, JP., Dawson, L., Smith, LM., & Gasson, N. (2008). The role of early fine and gross motor development on later motor and cognitive ability. *Human Movement Science, 27*, 668-681.
Pin, Tamis, Eldridge, Beverley, & Galea, Mary P. (2007). A review of the effects of sleep position, play position, and equipment use on motor development in infants. *Developmental Medicine & Child Neurology, 49*(11), 858-867.
Pollitt, Ernesto, Gorman, Kathleen S, Engle, Patrice L, Rivera, Juan A, & Martorell, Reynaldo. (1995). Nutrition in early life and the fulfillment of intellectual potential. *The Journal of nutrition, 125*(4), 1111S-1118S.
Power, Thomas G. (1999). *Play and exploration in children and animals*: Psychology Press.
Prado, E, & Dewey, K. (2012). Insight Nutrition and brain development in early life. *AT&T Technical Brief*(4), 48.
Ramirez-Zea, Manuel, Melgar, Paul, & Rivera, Juan A. (2010). INCAP Oriente Longitudinal Study: 40 years of history and legacy. *The Journal of Nutrition, 140*(2), 397-401.
Rogoff, B. (2003). The cultural nature of human development. Oxford University Press.
Rogoff, Barbara, Mistry, Jayanthi, Göncü, Artin, Mosier, Christine, Chavajay, Pablo, & Heath, Shirley Brice. (1993). Guided participation in cultural activity by toddlers and caregivers. *Monographs of the Society for Research in Child Development*, i-179.
Ruth, Linda Cain. (1999). *Design Standards for Children's Environments*. New York: McGraw-Hill.
Rutter, Michael. (1998). Developmental Catch-up, and Deficit, Following Adoption after Severe Global Early Privation. *Journal of Child Psychology and Psychiatry, 39*(4), 465-476.
Rutter, Michael, & O'Connor, Thomas G. (2004). Are there biological programming effects for psychological development? Findings from a study of Romanian adoptees. *Developmental Psychology, 40*(1), 81.
Rutter, Michael, Sonuga-Barke, Edmund J, Beckett, Celia, Castle, Jennifer, Kreppner, Jana, Kumsta, Robert, . . . Gunnar, Megan R. (2010). Deprivation-Specific Psychological Patterns: Effects of Institutional Deprivation. *Monographs of the Society for Research in Child Development, 75*(1), 1-252.
Schneider, Eleanor. (2009). Longitudinal observations of infants' object play behavior in the home context. *OTJR: Occupation, Participation and Health, 29*(2), 79.
Schwartzman, Helen B. (1980). *Play and culture: 1978 proceedings of the Associ-*

ation for the Anthropological Study of Play. Leisure Press.
Shore, Rima. (1997). Rethinking the brain: New insights into early development.
Shuk-Man Lau, Mandy. (2012). Reach&Match. Retrieved 6/1/2013
Shweder, Richard A. (1991). *Thinking through cultures: Expeditions in cultural psychology*. Harvard University Press.
Sonuga-Barke, Edmund J, Schlotz, Wolff, & Kreppner, Jana. (2010). V. Differentiating developmental trajectories for conduct, emotion, and peer problems following early deprivation. *Monographs of the Society for Research in Child Development, 75*(1), 102-124.
Stambak, Mira, & Verba, Mina. (1986). Organization of social play among toddlers: An ecological approach. *Process and outcome in peer relationships*, 229-247.
Steele, Fred I. (1973). *Physical settings and organization development*: Addison-Wesley Reading, MA.
Sutton-Smith, Brian. (1972). *The folkgames of children*: American Folklore Society.
UNICEF. (2006). Programming experiences in early child development. New York: Early Child Development Unit.
Vygotsky, Lev S. (1978). The role of play in development. *Mind in Society*, 92-104.
Walker, Susan P, Wachs, Theodore D, Meeks Gardner, Julie, Lozoff, Betsy, Wasserman, Gail A, Pollitt, Ernesto, & Carter, Julie A. (2007). Child development: Risk factors for adverse outcomes in developing countries. *The lancet, 369*(9556), 145-157.
WePlay. (2013). Octogon Blocks. Retrieved 6/2/2013
White, Burton L, & Held, Richard. (1966). Plasticity of sensorimotor development in the human infant. *The Causes of Behavior, 2*, 60-70.

Image Credits

Maleschka, M. (2011). Ceramic Relief Mural Dresden.
Dubuffet, J. (1974). Jardin d'émail.
Schmidt, R. (2005). BUGA Playground, Munich.
TaylorCullityLethlean (2000). Carlton Playground.
Diosdado, D. Caterpiller Tent.
Studio, D. a. (2010). Chaise Cork.
Siteworks (2012). Community Chalkboards.
Textiles, C. (2012). Crypton Kids' Home Accessories.
Kidco (2012). Kidco Peapod.
Ramos, E. V. (2011). Kindergarten in El Serrallo.
feld72 (2010). Kindergarten Terenten.
Design, M. (2012). Gradient.
Vinson, M. (2012). Myriad Crash Pad.
Urbanism, S. L. (2006). Safe Zone.
Architects, M. K. (2010). Remez Arlozorov.
Horiuchi, T. (2013). Kaleidoscape.
Parks, E. (2011). WindFisher.
Holt, K. (2009). A group of children sit on the step of their families temporary home in Epworth, in Harare, Zimbabwe., IRIN.
AL_A (2012). Bench of Plates.
ThoughtBarn (2012). PlayHive.
Images, L. (2013). LEGO Brick Field.