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Early Childhood Educational Toys through an Architectural Perspective

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Table of Contents


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Introduction ...04

Background ...08

- History of Early Childhood Education
- Arkansas Standards for Early Childhood Education
- Modern Pedagogies

Precedent Studies ...14

- Rigamajig - Cas Holman
- Anji Play - Cheng Xueqin
- Blockitecture - James Paulius
- Froebel Gifts - Friedrich Froebel

Design Process ...18

- Project Statement & Objectives
- Initial Design
- Prototyping & Testing
- Production

Review & Testing ...26

- Reviewers and Jean Tyson Child Development Study Center
- Research Protocols
- Trial 1
- Trial 2
- Trial 3

Conclusions ...36

References ...38

- Works Cited
- Appendix A - Data Collection Script & Questionnaire
- Appendix B - Parent Consent Form
- Appendix C - IRB Expedited Approval Letter
- Appendix D - Trial 1 Notes
- Appendix E - Trial 2 Notes

Introduction


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Abstract

This capstone explores the overlaps between architectural training and early childhood education, and how architectural design can inform the design process of creating educational toys for young children. Through an analysis of pedagogies used throughout history in early childhood education and my own personal experiences of architecture school, an understanding of how an architectural perspective can influence activities for three- to five-year-olds is developed. Precedent studies of open-ended educational toys designed by educators and designers introduced the design thinking mindset necessary to create an effectively enriching toy. The next phase of this project involves designing an educational toy for the given age group based off the principles derived from the background and research of early childhood education techniques. A project statement is then formed to determine intended effects of the educational toy and then a design process is initiated to achieve these results. The iterative process tests various textures, shapes, sizes, and connections. The designed toy was tested with a group of children in the targeted age range attending the Jean Tyson Child Development Study Center. Edits to the designed toy are made based off the children's verbal and indicated feedback and the trial is repeated to gauge success of functionality and the children's preferences. Although further and longer-term testing is required to determine the lasting educational effects of the toy, the design is evaluated using the initial project statement.

INTRODUCTION

Image by : Anindhitha Sudhakaran

The early years of one's education are fundamental to the overall educational experience and even later success in career. As early as between the ages of three and five, children learn fundamental skills and begin to develop complex skills that define their abilities throughout life. During this age, there is a major emphasis on kindergarten prep that includes motor skills refinement and creativity. Many pedagogical approaches such as the Montessori Method and the Reggio Emilia approach suggest that hands-on learning and creative thinking have immeasurable benefits that lead to success. The values of these pedagogies often overlap with that of architectural training. Incorporating design thinking with an architectural perspective into curriculum development or educational toys would draw from objectives highlighted in architectural education that could also help younger students develop fundamental and complex skills.

Figure 1 - Froebel Kindergarten; Image Source: https://ghdi.ghi-dc.org/sub image.cfm?image id=1684

HISTORY OF EARLY CHILDHOOD EDUCATION

A history of proposed strategies for early childhood education suggest that hands-on learning, creativity, open-ended teaching, and child-led learning are key to successful education of children between the ages of three and five as they prepare to start their K-12 education. Jean Jacques Rousseau was among the first to critically consider children's learning instincts and propose that investigation and self-initiated exploration is a powerful tool in early childhood education (Lang n.d.). He suggests that natural human curiosity is strongest during this age and therefore the most influential/influenced aspect of a child's developing brain. Rousseau's theories and philosophies revolve around the concept of natural human behavior. Specifically, he claims that children lack "bad habits" and simply react to the world around them in a pure manner (Rousseau 1762). He argues that this is why education at this age is so developmental. Introducing creative activities at this early age can yield lasting benefits of creative and critical thinking due to the mind's ability to be molded during this stage. Following Rousseau's impact on early childhood education, Friedrich Froebel had significant influence on early childhood education today through his introduction of the concept of "kindergarten" (Figure 1). Froebel observed that early childhood education, at the time, was based on teachers passing on knowledge to students through lessons or lectures. He theorized that young children's natural instincts such as curiosity and creativity should be utilized to teach more efficiently. This methodology became known as kindergarten and placed responsibility on the children to "grow and develop at their own pace" through activity and inquiry (Tovey 2017). Furthermore, Froebel made important suggestions regarding what educational tools and toys should look like. He famously insists that "the material for building in the beginning should consist of wooden blocks whose base is always one inch square and whose length varies from one to twelve inches" (Froebel 1826). He designed a series of 10 gifts for young children that took them through phases of learning.

Modern Pedagogies

Early childhood education centers today often cite modern teaching philosophies in the framework for their establishment. This allows parents to select and understand how their child is learning during these developmental years. In modern times, many pedagogies take open-ended approaches to allow for more opportunities for learning and preparedness for an increasingly complex world. This open-ended strategy where the child is the leader of their own education resembles accredited architecture programs around the country in which architecture students lead their own learning process through design and exploration.

The Montessori Method, developed in the 1900s by Maria Montessori, is one such pedagogy that is still utilized in early childhood education centers today. Maria Montessori's theory that efficient learning occurs when children pursue what they are interested in was inspired by Froebel's philosophy as well (Novak Djokovic Foundation - The Early Years Blog 2018). Both educators recognized a child's instinct to seek knowledge and argued to capitalize on this instinct to effectively teach. In Montessori schools today, classrooms are filled with sensory-based materials such as geometric solids with textures such as sandpaper and colored beads. For example, classrooms in the Sunnyside Micro-School, a school that follows the Montessori Approach, are set up to "develop [children's] concentration and coordination" (Stepien 2019). In addition to sensory materials in the toys, the Montessori approach argues for intentionally designed classroom atmospheres that make use of "lots of natural light and space" (Meinke 2019). Throughout Europe, specifically in Italy where it was founded, the Reggio Emilia Approach is being utilized in early childhood education. In addition to the child-led aspects that are shared with the Montessori approach, this approach suggests long-term and "in-depth project work based on the interests of the children" (Novak Djokovic Foundation - The Early Years Blog 2018). This includes creative media such as drawing, painting, and sculpting to encourage children to express themselves and the actions they are performing. The process proposed by Loris Malaguzzi, founder of the Reggio Emilia Approach, very closely describes architecture education and suggests that the process of drawing, describing, and reflecting results in deeper learning.

In the Zhejiang Province of China, educator Cheng Xueqin developed the methodology for Anji Play for the children in her county. In 1989, when China joined the United Nations Convention on the Rights of the Child, the nation pledged to protect a child's right to "rest and leisure, to engage in play and recreational activities...and to participate freely in cultural life and the arts." (Anji Play n.d.). Xueqin recognized the lack of these qualities in the schools in Anji county and wanted to introduce these values she resonated with. To understand how to do so, Xueqin considered what "true play" meant and asked herself and other adults what are the "deepest memories of play as a child". She determined that self-determination and a degree of risk stuck out in their fondest memories. In addition, she found an appreciation for "large, minimally structured materials and open-ended, minimally-structured materials." With these considerations, she began developing a set of play materials and creating the environments children used such structured materials in, to learn (Figure 3). Eventually, this would develop to be known as "Anji Play" which has now become a focus of the Ministry of Education in China and the concepts have been adopted in other schools. Observed benefits of this early childhood education style taught children how to "solve conflicts, remove danger, and create order." The Anji Play methodology highly reflects that of architecture training in which students are also prompted to "solve conflicts" and "create order". More importantly, in both scenarios, students are asked to describe their actions and decisions to better understand and learn from what they are doing.

As introduced by the Montessori method and Anji Play, the learning environment can have a significant impact on a child's experience. In Nature Based Preschool programs, children reap learning opportunities from the natural environment and the phenomena it showcases. By expanding the learning environment outside the traditional indoor classroom, the opportunities for teaching expand. The typical school day in a nature-based preschool is split between three categories of spaces – the indoor classroom, the outdoor classroom, and the beyond. Most of each day in the nature based preschool curriculum is spent outdoors, and the indoor classroom is mainly used for naptime or inclement weather. Lesson plans encourage children to observe creatures and elements in nature and describe what they see, introducing analytical thinking at an early age. Today, there are over 100 nature preschools throughout the world in which children take risks and lead their own learning experience (Natural Start Alliance n.d.). Although the Nature Based Preschool pedagogy doesn't occur in a traditional classroom that is deliberately designed for learning, children can build on any domain of development. This framework can enhance communication, promote environmental stewardship, foster ecological literacy, and much more that takes the educational quality above and beyond (Merrick, et al. 2019).

Although different methods of early childhood education focus on unique aspects, many of them indicate that young children are capable of more than one would think. By empowering and encouraging young children to lead their education, they can gain complex and impactful skills that help them throughout their education and beyond. A culmination of child-led learning and allowing them to learn in multiple ways and places can result in ideal early childhood education.

Figure 2 - Marie Montessori with students; Image Source: https://montessori-ami.org/resource-library/facts/biography-maria-montessori

Social and Emotional Development

SE1. Relationships with Others
- SE1.1 Forms trusting relationships with nurturing adults
- SE1.2 Interacts with peers

SE2. Emotional Expression and Understanding
- SE2.1 Experiences, expresses, and regulates a range of emotions
- SE2.2 Interprets and responds to the feelings of others

SE3. Self-Awareness and Self-Concept
- SE3.1 Shows awareness of self as unique individual
- SE3.2 Demonstrates competence and confidence

Cognitive Development

CD1. Approaches to Learning
- CD1.1 Shows curiosity and a willingness to try new things
- CD1.2 Shows persistence in approaching tasks

CD2. Executive Function
- CD2.1 Focuses and sustains attention
- CD2.2 Shows flexibility in adjusting thinking and behavior to different contexts
- CD2.3 Regulates impulses and behaviors
- CD2.4 Holds and manipulates information in memory

CD3. Logic and Reasoning
- CD3.1 Uses reasoning and planning ahead to solve problems and reach goals
- CD3.2 Engages in symbolic and abstract thinking

Physical Development and Health

PH1. Gross Motor
- PH1.1 Demonstrates locomotor skills
- PH1.2 Shows stability and balance
- PH1.3 Demonstrates gross-motor manipulative skills

PH2. Fine Motor
- PH2.1 Demonstrates fine-motor strength, control, and coordination
- PH2.2 Adjusts grasp and coordinates movements to use tools

PH3. Health and Well-Being
- PH3.1 Demonstrates interest in engaging in healthy eating habits and making nutritious food choices
- PH3.2 Shows awareness of safe behavior
- PH3.3 Engages in a variety of developmentally appropriate physical activities
- PH3.4 Takes appropriate actions to meet basic needs

Language Development

LD1. Receptive Language
- LD1.1. Understands and responds to language (in child's home language)

LD2. Expressive Language
- LD2.1. Uses increasingly complex vocabulary, grammar, and sentence structure (in child's home language)

LD3. Communication Skills
- LD3.1. Communicates using social and conversational rules

LD4. English Language Development of Dual Language Learners
- LD4.1. Demonstrates progress in attending to, understanding, and responding to English
- LD4.2. Demonstrates progress in speaking and expressing self in English

Emergent Literacy

EL1. Engagement in literacy experiences and understanding of stories and books
- EL1.1 Shows interest in literacy experiences
- EL1.2 Engages in read-alouds and conversations about books and stories

EL2. Phonological Awareness
- EL2.1 Notices and manipulates the sounds of language

EL3. Knowledge and Use of Books, Print, and Letters
- EL3.1 Responds to features of books and print
- EL3.2 Shows knowledge of the shapes, names, and sounds of letters
- EL3.3 Demonstrates emergent writing skills

Mathematical Thinking

MT1. Number Concepts and Operations
- MT1.1. Demonstrates number sense and an understanding of quantity
- MT1.2. Explores combining and separating groups (numerical operations)

MT2. Algebraic Thinking
- MT2.1. Uses classification and patterning skills

MT3. Measurement and Comparison
- MT3.1. Participates in exploratory measurement activities and compares objects

MT4. Geometry and Spatial Sense
- MT4.1. Explores and describes shapes and spatial relationships

Science and Technology

ST1. Scientific Practices
- ST1.1. Engages in the scientific process to collect, analyze, and communicate information

ST2. Knowledge of Science Concepts
- ST2.1 Demonstrates knowledge of core science ideas and concepts

ST3. Knowledge of Science Content
- ST3.1 Demonstrates knowledge of the characteristics of living things, the earth's environment, and physical objects and materials
- ST3.2 Uses tools and engineering practices to explore and solve problems
- ST3.3 Engages in developmentally appropriate interactions with technology and media that support creativity, exploration, and play

Social Studies

SS1. Family, Community, and Culture
- SS1.1 Demonstrates positive connection to family and community

SS2. History and Geography
- SS2.1 Shows awareness of sequence and change over time
- SS2.2 Demonstrates simple geographic knowledge

Creativity and Aesthetics

CA1. Music and Movement
- CA1.1. Explores through listening, singing, creating, and moving to music

CA2. Visual Arts
- CA2.1 Explores, manipulates, creates, and responds to a variety of art media

CA3. Drama
- CA3.1 Explores feelings, relationships, and concepts through imitation, pretend play, and sociodramatic play

Source: Arkansas Child Development and Early Learning Standards Committee. 2016. Arkansas Child Development and Early Learning Standards: Birth through 60 Months. Division of Child Care and Early Childhood Education.

Arkansas Standards for Early Childhood Education

In addition to looking toward existing teaching philosophies, each state's educational standards reveal what skills children need to acquire during each stage of development. The state of Arkansas developed documents outlining these benchmarks make it clear that ages three to five are critical for a child's development and focus on kindergarten readiness. Before children are taught to read and write in school, they are already prompted to perform complex tasks that require critical thinking. A designer's perspective can fit into this learning stage due to the emphasis on visual and physical skills seen in architecture and other design fields. Design activities, although simplified for the age group, can still address many domains of learning goals.

Specifically in Arkansas, an initiative was created to outline different learning standards for this critical childhood development stage. The goal was to clearly define what children between zero and sixty months need and to help educators and parents better give this to children. There are many domains of development and learning that need to be addressed to prepare a child for kindergarten and beyond. Analysis of this learning standards document reveals that design activities can address many of these strands including social and emotional development, cognitive development, physical development and health, language development, mathematical thinking, and creativity and aesthetics (Arkansas Child Development and Early Learning Standards Committee, 2016). Some categories are clearly design based, such as creativity and aesthetics. Hands-on design activities naturally address the requirements for physical development and creativity. Simple blocks and coloring activities are often used in early childhood classrooms to stimulate development. More complex and carefully designed toys and educational tools can pinpoint specific learning standards such as fine and gross motor skill development. Designing for a specific solution is in an architect's repertoire of skills and could produce unique and beneficial learning tools for children. Carefully crafted design activities can address some of the social and communicative skills that children need exposure to. Drawing from the architecture curriculum, where students are often asked to describe their work and explain their decisions, these activities for younger children can take on an additional level of appropriate complexity. When design activities are used in early childhood education, children can be asked to similarly describe their actions and their choices. This simple task can address the domains of social and emotional development, cognitive development, and language development.

Precedent Studies

Images source: https://casholman.com/design/rigamajig

Rigamajig | Cas Holman

Rigamajig is a prime example of an open-ended design activity that allows children to maximize their creative thinking, and designer Cas Holman made this a priority when designing the Rigamajig. She identified how today's "design world doesn't leave much room for [kids] to explore" and she wanted to change this through her work (Holman, The Case for Letting Kids Design their Own Play 2015). The learning tool consists of wooden pieces with connection points and various connective materials depending on the different types of kits. The connective elements are what makes this educational toy unique and challenges children to exercise new motor skills. There is a "Basic Builder Kit" that maintains the highest degree of open-endedness. However, there are more specific workshop options that teach certain concepts such as simple machines. Overall, these educational toys empower children to create at an early age, showing them first-hand how design can influence the world around us.

Images source: https://cdn.connox.com/m/100107/231961/media/areaware/Blockitecture/AreawareBlockitecture-GardenCity-Architektur-Parkland-Freisteller.jpg

Blockitecture | James Paulius

Blockitecture is a more literal form of a toy that encourages young children to think like designers or architects. The blocks resemble building facades, pathways, roads, etc., and prompt children to arrange them in different ways. The opportunity for different combinations is a good learning opportunity but restricts a child's imaginative and creative process. However, there are many different types of Blockitecture kits that teach children about different designed environments such as a Greenway, Factory, Desert Garden, etc.

Image Source: http://www.anjiplay.com/materials

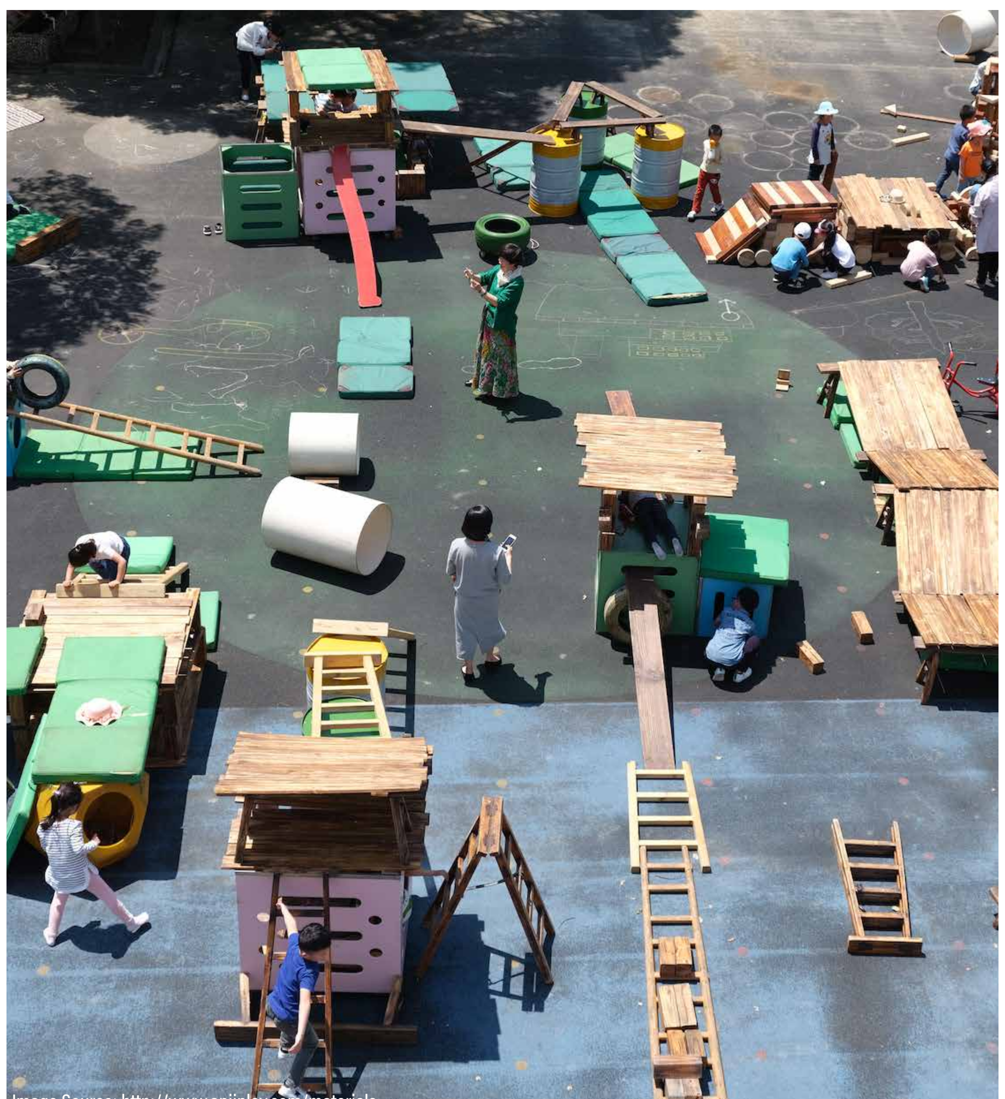

Image Source: http://www.anjiplay.com/materials

Anji Play | Cheng Xueqin

Anji Play is a comprehensive curriculum that additionally includes educational materials and toys that are incorporated into the carefully crafted environment. All the materials used in an Anji Play school are meant to be open-ended so that children can apply their imaginations to the abstract tools they are provided. Examples of the materials include blocks, planks, ladders, climbing cubes, and storage systems that founder Cheng Xueqin developed herself. These play materials also take on varying scales to maximize learning opportunities. The larger pieces empower children in this learning model and maximize their realization of what they can achieve. In general, this gives the children control of their own learning environment and consequently increases interest in what they are learning (Anji Play n.d.).

Images Source: http://froebelgifts.com/

Frobel Gifts | Friedrich Froebel

Froebel gifts are designed to encourage education and impact children during a critical developmental stage. Each gift builds off this notion of minimalistic blocks that allow for maximized learning. Froebel was led to design these educational toys because he observed that many modern toys were "unsuitable for children, because they discouraged discovery and creativity" (Sillanpää, Visuri and Ruokonen 2022). He advocated for the abstract nature of simple blocks instead which allowed for children's imaginations to run wild. He vividly describes how the Froebel Gifts and similar blocks are intended to help children "feel and experience, to act and represent, to think and recognize" unlike the other toys he criticized for lack of educational opportunity. For many years, educators and philosophers have noticed unreached potential in the realm of early childhood education and most agree that letting a child's instincts lead is the answer. Gifts 2, 3, 4 and 5 consist of simply geometric shapes that can be stacked and arranged. They are meant to be ideal for younger children between the ages of three and four and build on their natural curiosities and emerging instincts. The minimalistic design of this toy demonstrates how open-endedness can result in unrestricted learning opportunities. Gift 10 adds complexity through a "gradual shift from the concrete idea of solid forms to the abstract idea of 'spatial patterns" (Sillanpää, Visuri and Ruokonen 2022).

Design Process

Creative Thinking, Problem Solving, Form Building, Motor Skill Development

SE 3.1
Communicates preferences and interests and shows increasing ability to explain their likes and dislikes

CD 1.1
Experiments with objects and materials with increasing ability to explain their likes and dislikes

CD 3.1
Shows increasing ability to independently and collaboratively make choices, plan for play scenarios, and anticipate problems

PH 2.1
Handles smaller blocks, puzzle pieces, and manipulatives
Manipulates a variety of fasteners with increasing skill, such as buttons, zippers, laces, and buckles
Manipulates more complex fasteners

MT 1.2
Using fingers or manipulatives as tools, shows increasing ability to solve simple addition problems by joining objects together for increasingly larger totals

ST 2.1
Identifies parts of a whole
Makes observations and generalizations about structure and function

ST 3.2
Explores and later in this age range identifies simple machines such as ramps, gears,
wheels, pulleys, and levers through play experiences

CA 2.1
Shows increasing range and intentionality in art creations
Tells about their artistic creations with increasing detail
Chooses their own art for display in the learning environment or for inclusion in a book and briefly explains their choice
Communicates with others about art by discussing the ideas behind their own art

Figure 8 - Project Objectives; Diagram by: Anindhitha Sudhakaran

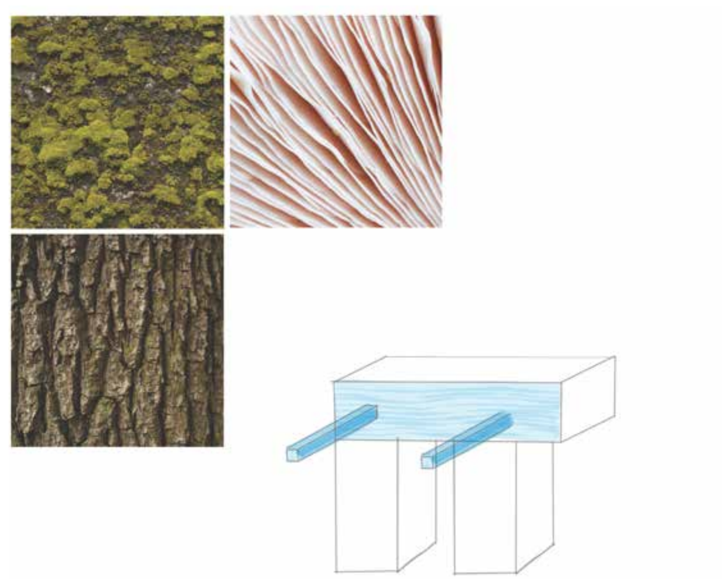

Figure 9 -Initial sketches; Drawings by: Anindhitha Sudhakaran

Recurring themes that were endorsed throughout different teaching methodologies and the professional opinions of educators throughout time include self-led learning, play, and open-endedness. Therefore, the design process for this capstone project aiming to develop an educational tool/toy for children ages three to five takes on the challenge of maintaining minimality. Specifically, Froebel's statement that "the material for building in the beginning should consist of a number of wooden blocks whose base is always one inch square and whose length varies from one to twelve inches" drives the concept of this design process. In initial sketches, some complex or unique forms for the toy were explored, but these began to leave less room for a child's imagination. The determination to pursue simple block shapes and explore connection methods was eventually made.

An initial analysis of the intended goals/ objectives for this educational toy also drove the design process. To begin, the age group of three to five was selected to introduce these skills at an early age. Specifically, this age proves to be crucial for kindergarten development and has lasting impacts throughout a child's education (Arkansas Child Development and Early Learning Standards Committee, 2016). Pedagogies such as the Reggio Emilia Approach and Anji Play demonstrate that children can create impressive artwork and structures when allowed to exercise choice making and given the right tools. The final product should generally encourage creative thinking, problem solving, form building, and motor skill development because these skills encourage complex thinking and can elevate standard education (Figure 8). In addition, the research process combined with an understanding of Arkansas's standards for child development at this age range informed the following project statement.

In order to elevate the concept and offer an added aspect of stimulation, the natural environment was prioritized in the design process. Many educators and pedagogies commend the natural environment for the valuable lessons it offers and the fact that children are instinctively drawn to it. Expanding the learning environment to that outside of the classroom has proven to yield certain benefits as demonstrated by the Nature Based Preschool framework. In fact, Rigamajig designer Cas Holman also notes that sticks and rocks are ideal toys for children because they can be "appropriated for play" (Holman, The Case for Letting Kids Design their Own Play 2015). Therefore, the goal to include some aspect of nature is established to broaden stimulation of the mind and senses.

As with any design project, after case studies comes initial sketches and brainstorming. Images with natural patterns were a point of inspiration from which form was interpreted. The concept of building blocks and connections, as Froebel and others advocated for, were investigated to extreme and simple degrees. Considering structural phenomena in the natural environment, concepts such as mushroom spores or knots on a tree trunk were explored (Figure 9). The act of slotting or inserting additional pieces was derived from this phenomenon and carried forward to the first prototype.

Iteration 1

Figure 10 - Iteration 1; Images by: Anindhitha Sudhakaran

In the first iteration, natural textures explored in the preliminary sketches were simply cut out of sheets of plywood and used to create blocks. Blue insulation foam was included in the center of the block for stick elements to be inserted and slotted through the cutouts in the wooden patterns. The initial size of the blocks from this first iteration are blocks of two inches by two inches and two inches by four inches. Although this is larger than Froebel's guidelines, this allowed for more surface area to explore and analyze textures and their effects. Dowels and sticks of different sizes were explored as connectors (Figure 10). The most successful aspect of this iteration was the sensory opportunities from the cutouts and a sense of open-endedness in where sticks could be inserted. These aspects were beneficial because they uphold the intentions of the project which include open-ended play that gives the children control of their own education. However, the level of open-endedness proved to have some downfalls such as a lack of structural integrity when creating forms with the blocks and sticks.

Iteration 2

Figure 11 - Iteration 2 slotting technique; Images by: Anindhitha Sudhakaran

Figure 12 - Iteration 2 size and material explorations; Images by: Anindhitha Sudhakaran

In the second iteration, other construction techniques were explored to allow for moments of connection. Layering of the connectors could result in surface conditions and leaving room for slots allow for such moments of connection (Figure 11). The intentionally spaced slots that perfectly fit the size of the connector sticks resulted in some more structural stability when joining blocks. Furthermore, other block sizes and materials were also explored with the same laser etching technique as iteration one. For instance, the wood grain and leaf vein patterns were etched onto acrylic for a semi-transparent face (Figure 12). The use of acrylic opened up the opportunity for observation of what happens inside these blocks that children can make structures with. This addition was determined to be a potential learning opportunity and moved forward in future iterations.

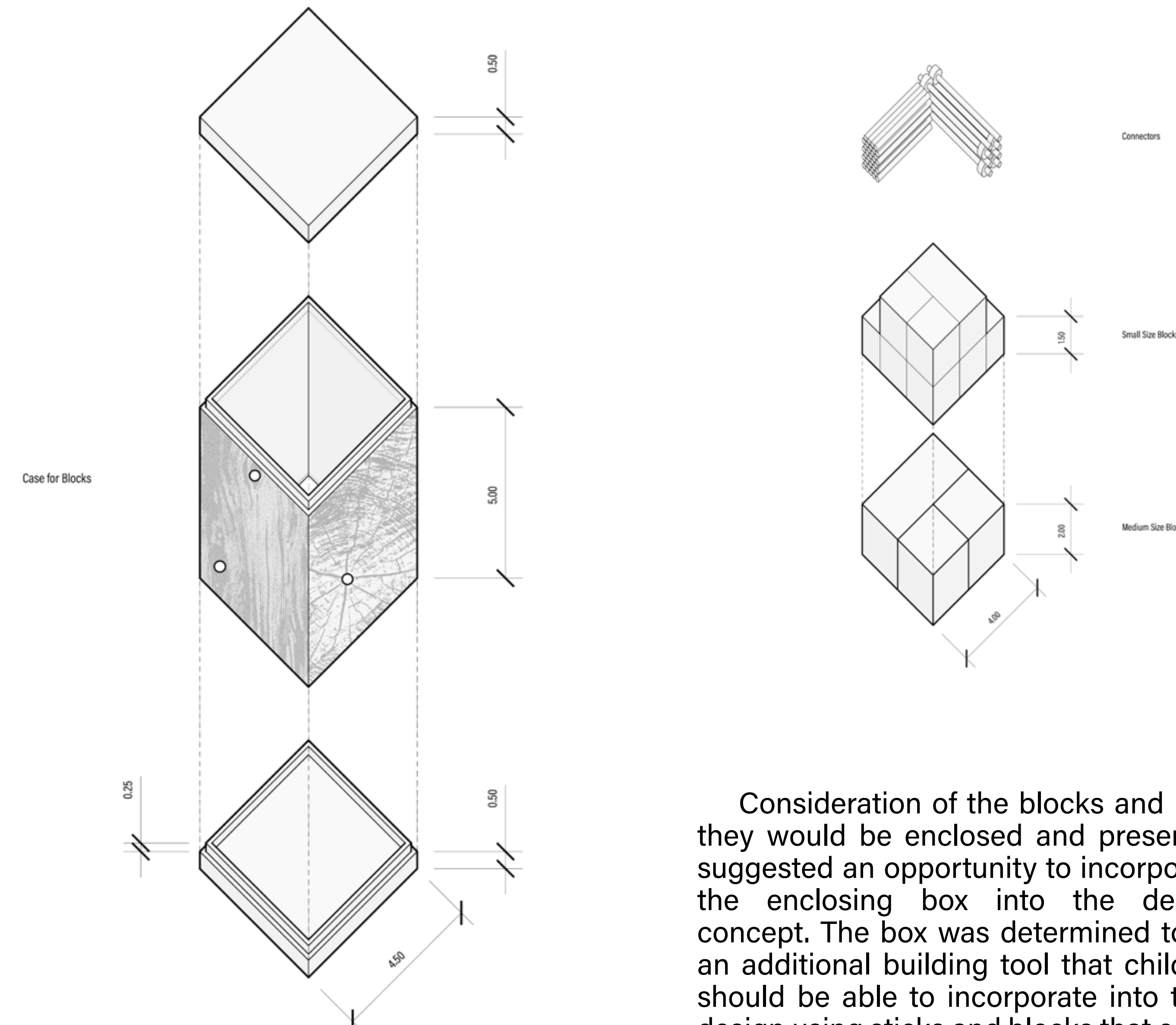

Figure 13 - Box design exploration; Diagram by: Anindhitha Sudhakaran

Consideration of the blocks and how they would be enclosed and presented suggested an opportunity to incorporate the enclosing box into the design concept. The box was determined to be an additional building tool that children should be able to incorporate into their design using sticks and blocks that could be inserted into the box itself (Figure 13).

Iteration 3

Figure 14 - Final toy design produced for beta testing

After these options were explored, a refinement stage narrowed down the options to determine the most effective aspects that upheld the educational goals of this toy. The larger block scale of a 2" base was selected for maximized surface area for sensory stimulation. It was also decided to use a single connector type – ¼" dowels – so as not to create confusion for younger children. Some additional textural materials that were most successful moved onto this stage, which included cork and Velcro. The Velcro offered one unique structural connection opportunity to further stimulate the children without causing confusion with stick connections. Furthermore, a specific number of block types were also determined- four cubes, two rectangular prisms and three "special blocks" with the more unique materials including cork, Velcro, and acrylic. This mix was selected to gauge interest and see what the children preferred. This final prototype was fabricated for testing with a study group (Figure 14).

Review & Testing

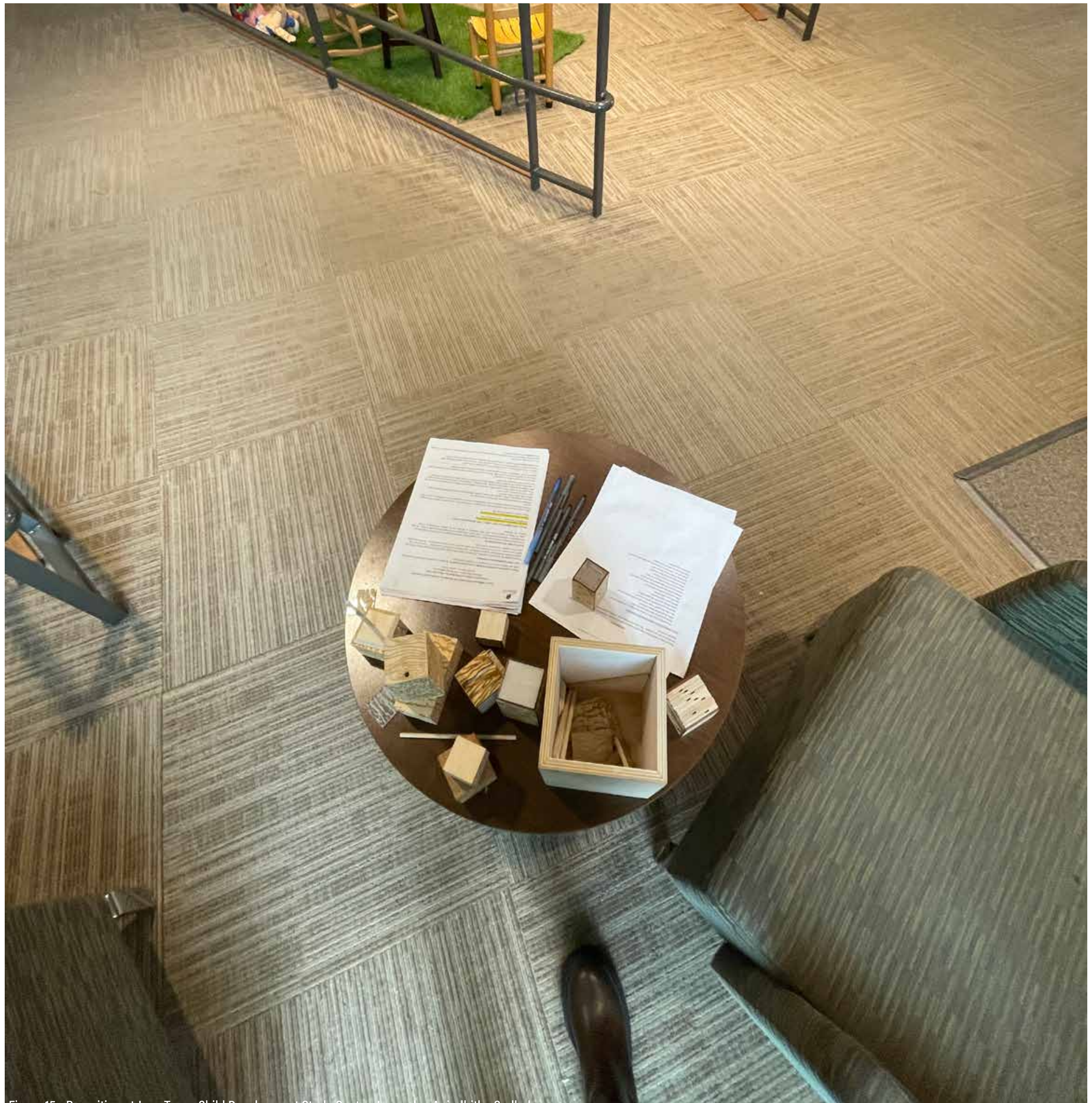
Figure 15 - Recruiting at Jean Tyson Child Development Study Center; Image by: Anindhitha Sudhakaran

To receive well-rounded feedback on the design development of this educational toy, a committee of different reviewers from the University of Arkansas were regularly called upon to provide their professional opinions. This included faculty from the Architecture department of the Fay Jones School of Architecture + Design and the Art Education Program in the School of Art.

The ideal feedback on this educational toy would come from people in the intended user group – children between the ages of three and five. Understanding the effectiveness of the design through informal questioning, photographs, and even video recordings of trials would be beneficial to the design process. Collaboration with the University of Arkansas's Jean Tyson Child Development Study Center (JTCDSC) was initiated to recruit children and teachers to provide additional feedback. Initial stages of feedback were mainly from teachers and administrators at the JTCDSC. This informed iterations and narrowing down of certain material choices, sizes, textures, etc. The initiative to work with human subjects, especially children, in this research study required completing an Institutional Review Board review. In the IRB protocol, the target age range was further reiterated, and safety measures were established. It was determined that the tests (up to two rounds) could include between five and ten students. A script for data collection (Appendix A), explaining the study to the children, was developed to gauge consent from the children as well. Each trial could last up to one hour long and the script included instructions that the children could opt out of a trial at any point. All this information was compiled and included in a parent consent form (Appendix B). The recruiting process occurred during child pick up on April 4th, 2023 (Figure 15). Parents were presented with the IRB approved materials (Appendix C) and prototypes of the toy were displayed to demonstrate the extent of the study. Some parents signed the consent form during that day, and some returned a signed permission slip to the JTCDSC a few days later.

Once a thorough design and production process for the educational toy was reached, production of enough kits for each student at each trial round was produced. Through meeting with the director of the JTCDSC, it was determined that the sample group of children would be split into two groups of four. Therefore, five sets of toys were produced for testing.

Figure 16 - Fabrication process for beta testing; Images by: Anindhitha Sudhakaran

The production process entailed over 10 hours of laser cutting, 600 miter cuts, and many drilled holes (Figure 16). Efficiencies were developed to set up repeated cuts for an intentional process. Mastering the craft proved to be a learning curve in which practice and learning new techniques continue to better the results. Some areas fell short of the highest quality of craft in this first production round but a solution was identified for future production. Specifically, the last miter cut for the faces of the blocks proved to twist when cut with the table saw. However, craft techniques were identified for future production stages.

Once four sets – one for each student in one trial group – were created, testing began at the JTCDSC on April 24th, 2023. Groups of students pulled for each trial aimed to cover an even spread of demographics including gender, age, and race/ethnicity – this process was assisted by teachers at the JTCDSC who were familiar with the children.

Figure 17 - Trial 1 at JTCDSC ; Images by: Anindhitha Sudhakaran

Trial 1 | April 24th, 2023

The first trial (Appendix D) consisted of four students, all aged four. Two students were male and two were female. The planned script explaining the study to the children and their free will to stop participating at any time was read to the students. The students were asked if they wanted to play with the toy designed and all of them agreed. One student, however, lost interest about fifteen minutes into the trial because he expressed that he was tired. A teacher at JTCDSC then escorted him away. Another student followed his lead, but she soon returned because she wanted to continue working on her "garden" that she started. The other two students demonstrated interest for a full hour and gave feedback and requests for a potential second round of play. Some issues that arose were related to the craft of this first set of blocks. The blocks were initially hard to take out of the box they came in and some of the lids were difficult to remove and close. Only two students chose to use the box in their created structures. In terms of edits in the design of the toy, these three students overall agreed that they wanted/needed more sticks to fulfill their creations and decisions. A lot of collaboration occurred between students to share blocks and sticks. Their creations varied in scale, pieces included, height, etc. (Figure 17).

Trial 2 | April 26th, 2023

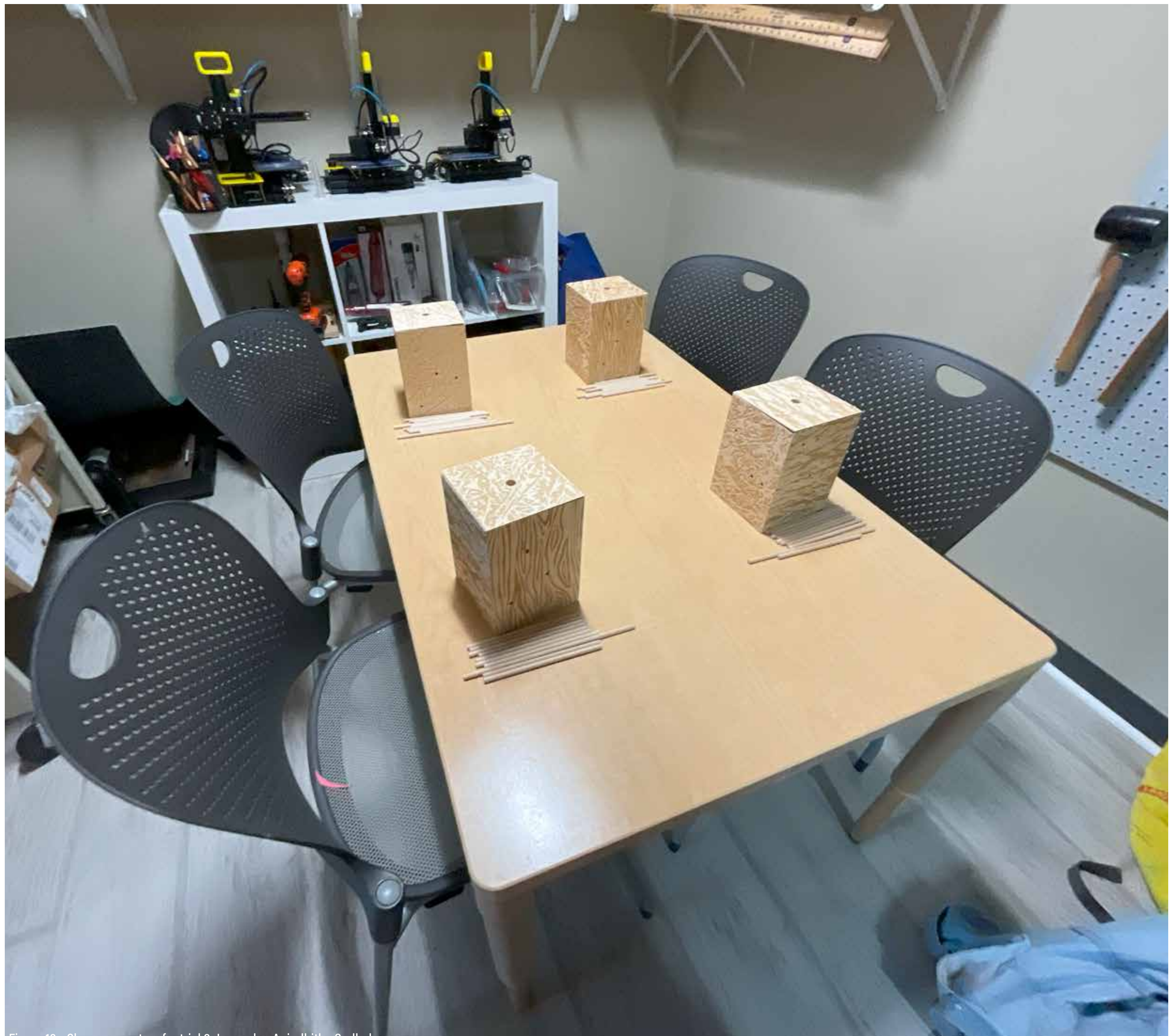

Figure 18 - Classroom set up for trial 2; Image by: Anindhitha Sudhakaran

The second trial (Appendix E) occurred on April 26th and consisted of three students. The study group included one four-year-old boy, one four-year-old girl, and one five-year old girl. Before the script explaining the project and the children's right to stop participating at any time was explained, the children began making many observations and opening their toys. This time, the sticks that come with each set were placed beside the box rather than inside because of the difficulty it posed in the last trial (Figure 18). This strategy significantly helped the students retrieve the blocks out of the box. In the previous trial, the students mentioned that they would want more sticks, so more were provided in this trial. When the study began, one student immediately noticed the holes and that she could see through them. She began stacking the blocks vertically, adding sticks when necessary to create stability. Once she was done with that, she explored how she could arrange the pieces horizontally. She placed blocks side by side and inserted sticks on top, sticking up. Another student was interested in the box - she carefully took out all the blocks inside and inserted a stick through the big box and spun it around by the stick. She then explored different ways she could stack the blocks back into the box, arrange the blocks and put the box on top, etc. The last student was interested in the box as well and pushed his box near the first student's to collaborate with her. He even used the lid of the box to create a "tree" (Figure 19). Overall, the students also took interest in the Velcro sides. When asked what their favorite parts to touch/feel were, some students referred to the soft sides of the Velcro and one student mentioned the "sticky" side. At one point, one student mentioned wanting to connect the blocks in an offset manner, to which the five-year-old student suggested she use the Velcro. There were some technical difficulties in which the Velcro would come apart from the wooden block – this will be repaired and incorporated into a final design suggestion for this project.

Figure 19 - Male four-year-old student's "tree" creation; Image by: Anindhitha Sudhakaran


Figure 20 - Snapshot from recording of trial 3; Image courtesy of: Jean Tyson Child Development Study Center

Trial 3 | May 3rd, 2023

In the third and final test, the toy set was reconsidered to gauge and answer some remaining uncertainties. For instance, the question of "which parts do you like to feel" was always answered referring to the Velcro. This caused uncertainty regarding whether the etched patterns were influential in any way to the students. To gain some clarity, some plain blocks with no textures were created and put into each set. The Velcro was excluded from this trial because the repairs were not cured yet. For this round, students from previous rounds who showed interest were brought back and an additional three-year-old was included to understand interest and capabilities of that age (Figure 20).

When the students entered the room, they came and found a spot and the usual script explaining the study and the children's rights were read to them. Approximately five minutes were allowed for the children to unpack their kits and observe. Following this initial observation, students from previous trials were asked if they noticed anything new about the set today. The female five-year-old student immediately recognized the plain blocks without texture. When asked what they thought of these blocks in comparison to the ones with no texture, two students described how they liked the textured blocks because of the way they felt. The children's feedback confirmed the idea that sensory stimulation added to simple forms could be enriching, as Froebel and the Natural Start Alliance suggest. The students from previous trials continued stacking and combining the toys and described their creations such as a walkie talkie, magic tricks, a remote control for sound, a hammer, etc. The three-year-old student quietly worked by herself during the trial and practiced inserting sticks into multiple blocks and laying them side by side (Figure 21) and stacking some of them on top of the box. Overall, the trial lasted approximately 17 minutes, which was shorter than other trials that lasted nearly a full hour. This trial was also able to be recorded in the Jean Tyson Child Development Study Center's library, following the IRB protocol approval.


Figure 21 - Female three-year-old child's creation from trial 3

Conclusions

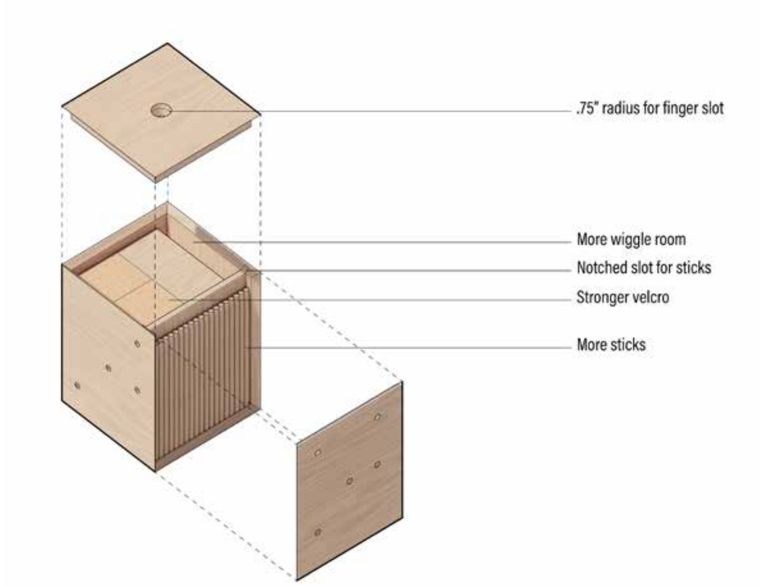

Figure 22 - Design improvement recommendations; Diagram by: Anindhitha Sudhakaran

Figure 24 - Scale explorations; Drawing by: Anindhitha Sudhakaran

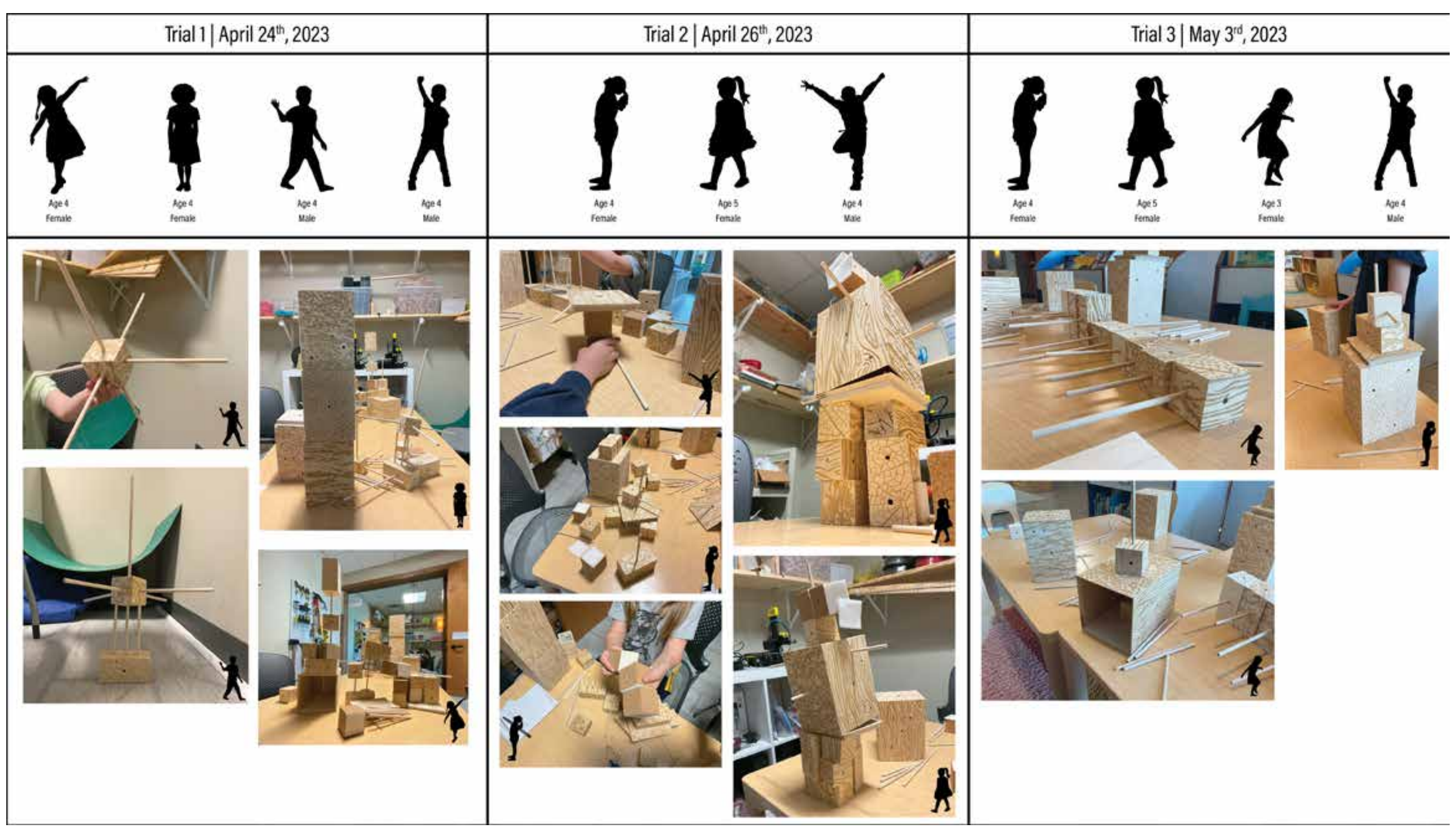

Figure 23 - Trials summary; Diagram by: Anindhitha Sudhakaran

According to the initial project statement describing the goals of the designed educational toy (Figure 8), the final design iteration used in testing successfully allowed children to exercise decision and choice making to create forms and structures. The questions asked remained abstract to allow the student's interpretations and visions to remain uninhibited, however students described their unique creations such as a garden, palace, walkie talkie, bees, and more. Although design professionals such as Cas Holman advocate for this strategy of minimal teacher intervention, children's imaginations naturally come forward as they describe their actions. The important takeaway is that, in these trials, their creativity was encouraged, and they were able to explain the choices they were making. Without questioning from myself or the JTCDSC teachers, children instinctively used design-based words to showcase their creations. Specific lesson plans with instructions on how teachers can ask open-ended questions and frame the toy as an educational toy would help in presenting this design as a toy to be used in educational establishments. Further long-term studies would be required to analyze how effectively this toy teaches creative thinking and problem solving in comparison to other tools.

The overarching skills targeted by this educational toy are creative thinking, problem solving, form building, and motor skill development. The students clearly demonstrated creative thinking through their eagerness to connect blocks in various ways to create something. Their descriptions of their creations helped them communicate their choice-making skills and understand what they were doing and why. As the students ran into problems, they worked together to solve them. When one student had difficulty putting all the pieces back in the box, another student piped up to help him. This was just one example of how the students shared their observations and knowledge to help each other achieve their goals.

Some design aspects of the final prototype posed challenges that require amendment. For instance, the Velcro, which highly interested the students, often came apart from the wooden block. Crafting studies were initiated to identify stronger glue and additional strength of staples were added to address this. The students also struggled with taking the blocks and sticks out of the box because the sticks would slant and get lodged. This can be addressed by creating a separate slot in the box for the sticks, so they don't interfere with the blocks (Figure 22). More room in the box overall would also help the children navigate the unboxing and re-boxing process, which is an enriching aspect of the activity.

After three trials, much was revealed about the process of getting children's feedback on a design project (Figure 23). They responded much better to stating their preference between options given rather than open ended questions. Further trials could include more texture, color, material, and formal options to identify other enriching block types. Other scales of these blocks and the boxes could be explored to create larger pieces that children can occupy, or smaller pieces to refine fine motor skills (Figure 24).

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Appendix A - Data Collection Script & Questionnaire

Data Collection Interview Script

Hello! My name is Ani and I am an architecture student! I am designing a new toy and I was wondering if you all could help me by playing with it and telling me what you think? Do you want to play with this toy?

If you want to stop playing at any time, just tell me or *teacher's name* and you can stop.

if the children say yes or take the toy, this is considered to meet full consent standard

Let me show you a couple ways to play with this toy. There are some block pieces and some connector pieces you can use to create whatever you like!

Questionnaire

The questions listed below may not be asked in this exact order. Questions will be dispersed throughout the duration of each session. This same list of questions will be sampled from during each of the two possible sessions.

Other questions to be asked during data collection:

- Do you have any ideas of what you might make with this toy?
- What do you see when you see this toy?
- What do you think about this toy?
- Does the toy work? If not, what can we do to fix the toy?
- What do you like/dislike about the toy?
- Which blocks are your favorite? Why?
- Which parts feel the best?
- How did you make that?
- What would you add or take away?
- What else do you need to make what you want to?
- What would you take away from this toy?
- What part of this toy do you not like?
- What would you name this toy?
- Who would you share this toy with?
- Is this toy hard or easy to play with?
- Does this toy remind you of anything you have seen before?
- Would you play with this toy again?
- Are you having fun?

UNIVERSITY OF ARKANSAS

Early Childhood Educational Tool through an Architectural Perspective

Consent for a Minor to Participate in a Research Study

Principal Researcher: Anindhitha Sudhakaran
Faculty Advisor: Alison Turner

This is a parental permission form for research participation. It contains important information about this study and what to expect if you permit your child to participate.

Your child's participation is voluntary.

Please consider the information carefully. Feel free to discuss the study with your friends and family and to ask questions before making your decision whether or not to permit your child to participate. If you permit your child to participate, you will be asked to sign this form and will receive a copy of the form. We must also have your child's assent to participate in this study.

INVITATION TO PARTICIPATE

Your child is being invited to participate in a research study about designing an early childhood educational tool through an architectural perspective. Your child is being asked to participate in this study because the age range of focus is three to five and child feedback is valuable to the design development of this project for children.

WHAT YOU SHOULD KNOW ABOUT THE RESEARCH STUDY

Principal Research's name and contact information
Anindhitha Sudhakaran - asudhaka@uark.edu

Faculty Advisor's name and contact information
Alison Turner - amturner@uark.edu

What is the purpose of this research study? The purpose of this study is to understand the effects and potential benefits of an architectural perspective when developing activities to educate children between the ages of three and five.

Number of expected participants, who they are, age range, etc.
Expected participants of this study are five to ten students from the Jean Tyson Child Development Center between the ages of three and five.

What will your child be asked to do?
Your child will be asked if they want to play with the toys designed and provided by the principal researcher. If your child says yes and/or takes the toy to play, they will play with the group of participants for one hour max or until they chose to be finished. They will be asked some questions by the principal researcher about their experience (list of questions provided).

What are the possible risks or discomforts?
There are no significant risks to your child. The toys provided by the principal researcher will be inspected and approved by Dr. McNally for safety standards before they are introduced to the children.

What are the possible benefits to your child if he/she participates in this study?
The goal of the toy designed/tested is to refine gross/fine motor skills, promote creative thinking, and encourage problem solving skills. Another goal is that children will have fun playing with the toy.

How long will the study last?
The principal researcher will meet with the participant group for a maximum of one hour at a time with a maximum of two meetings on separate occasions.

UNIVERSITY OF ARKANSAS

Will your child receive compensation for time and inconvenience if you choose to allow him/her to participate in this study?
No

Will you or your child have to pay for anything?
No

What are the options if I do not want my child to be in the study?
If you do not want your child to be in this study, you may refuse to allow him/her to participate. Your child may refuse to participate even if you give permission. If your child decides to participate and then changes his/her mind, your child may quit participating at any time. Your child's grades, relationship with their school or teacher, etc. will not be affected in any way if you or your child refuse to participate. Your child will not be punished or discriminated against in any way if you refuse to allow participation or if your child chooses not to participate.

How will my child's confidentiality be protected?
All information will be kept confidential to the extent allowed by applicable State and Federal law and University policy. Your child will be recorded in a classroom at the Jean Tyson Child Development Center during the study and video clips of your child may be included in a research presentation at the Fay Jones School of Architecture and Design. However, audio and your child's name will not be used in any report, presentation, or publication resulting from this research.

Will my child and/or I know the results of the study?
At the conclusion of the study you will have the right to request feedback about the results. You may contact the faculty advisor, Alison Turner, or Principal Researcher, Anindhitha Sudhakaran for any information following the study. You will receive a copy of this form for your files.

What do I do if I have questions about the research study?
You have the right to contact the Principal Researcher or Faculty Advisor as listed below for any concerns that you may have.

Principal Research's name and contact information
Anindhitha Sudhakaran - asudhaka@uark.edu

Faculty Advisor's name and contact information
Alison Turner - amturner@uark.edu

You may also contact the University of Arkansas Research Integrity and Compliance office listed below if you have questions about your rights as a participant, or to discuss any concerns about, or problems with the research.

Ro Windwalker, CIP
Institutional Review Board Coordinator
Research Integrity and Compliance
University of Arkansas
105 MLKG Building
Fayetteville, AR 72701-1201
479-575-2208
irb@uark.edu

Appendix C - IRB Expedited Approval Letter

UNIVERSITY OF ARKANSAS

To: Alison Turner

From: Douglas J Adams, Chair
IRB Expedited Review

Date: 04/03/2023

Action: **Expedited Approval**

Action Date: 04/03/2023

Protocol #: 2302453981

Study Title: Early Childhood Education Tool through an Architectural Perspective

Expiration Date: 03/07/2024

Last Approval Date:

The above-referenced protocol has been approved following expedited review by the IRB Committee that oversees research with human subjects.

If the research involves collaboration with another institution then the research cannot commence until the Committee receives written notification of approval from the collaborating institution's IRB.

It is the Principal Investigator's responsibility to obtain review and continued approval before the expiration date.

Protocols are approved for a maximum period of one year. You may not continue any research activity beyond the expiration date without Committee approval. Please submit continuation requests early enough to allow sufficient time for review. Failure to receive approval for continuation before the expiration date will result in the automatic suspension of the approval of this protocol. Information collected following suspension is unapproved research and cannot be reported or published as research data. If you do not wish continued approval, please notify the Committee of the study closure.

Adverse Events: Any serious or unexpected adverse event must be reported to the IRB Committee within 48 hours. All other adverse events should be reported within 10 working days.

Amendments: If you wish to change any aspect of this study, such as the procedures, the consent forms, study personnel, or number of participants, please submit an amendment to the IRB. All changes must be approved by the IRB Committee before they can be initiated.

You must maintain a research file for at least 3 years after completion of the study. This file should include all correspondence with the IRB Committee, original signed consent forms, and study data.

cc: Shelley McNally, Investigator
Rachel Smith Loerts, Investigator
Angela M LaPorte, Investigator
Anindhitha Sudhakaran, Key Personnel

Appendix D - Trial 1 Notes

Trial 1 (04/24/2023)

4 Students and 1 Teacher

Student 1 (Male, Age 4) played with some blocks for a little while and made a bird with one or two blocks and a couple sticks. He said he was tired after about 15 minutes and asked to stop.

Student 2 (Female, Age 4) started to make a garden but asked to stop when Student 1 did. She later came back and continued working on her garden because it wasn't ready for pictures. Student 2 found interest in the smaller versions of the blocks as well as the larger boxes that held the blocks. The older iterations with smaller blocks had some differently shaped holes and she requested that I bring them next time. She practiced stacking them and balancing them. She struggled with closing the box lids (need to be calibrated and crafted better). However, with some suggestions, she turned and manipulated the lid so that it would eventually fit. She added blocks inside the boxes and restacked them and even put the empty box on her head like a hat. Student 2 mentioned some colors such as purple and pink while playing with them and suggested she might add colors to some faces of the blocks. She described her tower of boxes as a beehive and said she was catching honey. The holes were for bees to go inside and taste honey.

Student 2's Creation

Student 3 (Male, Age 4) was interested in small configurations with one block and multiple sticks. He continued to add sticks into different sides and named them accordingly. He described his creation as bees, moose, etc. He was interested in playing bees vs bad guys. He mistook Student 3's creation for a bad guy and was hitting it. Student 3 and Student 2 spoke, and Student 3 asked Student 2 not to do that because she didn't want to play that game. Student 2 enjoyed having pictures taken of his creations. At one point, Student 2 joined two of his creations but remained drawn to the simpler ones. The textures reminded him of grass. He also liked some of the clear sides as well. Some of the holes were too small for the sticks and he struggled to join them. Student 2 said he wouldn't change anything about the toys but wanted more sticks and blocks to play with.

Student 3's Creations

Student 4 (Female, Age 5) worked with the Teacher and immediately asked to collaborate with her. She started by saying she was going to make a building and Student 3 said he was too. She added blocks and lots of sticks to her structure. The Teacher helped by holding some things in place. Student 4 described that there were boats and water around her building. She asked some of her classmates to borrow some of their sticks to make a stick bridge. There was a lot of sharing and collaboration because all the children wanted more sticks and blocks. Student 4 requested more sticks and blocks for next time to add to her palace. She also had some figurines in her backpack that she asked to play with her creation. She had two princess dolls and she allocated rooms for them. All the students discussed Moana and Tiana, water, frogs, etc. When Student 2 asked where the dolls' blankets were while they were sleeping, Student 4 used some of the Velcro material to create them.

Student 4's Creations

Appendix D - Trial 1 Notes

Overall, there was a consensus for wanting more sticks and a couple more blocks. When asked what else they would want/need to do what they wanted, there weren't any clear specifications. Discussion of color was brought up, but not a huge concern for any of the students. They compared a lot of their creations to animals, critters, etc. A couple students mentioned wanting to create structures such as buildings, palaces, and bridges. In terms of texture, the students liked the soft and prickly sides of the Velcro but didn't necessarily use them to create connections/structures. There was some initial hesitation/struggle in getting the blocks out of the box because the loose sticks were creating some tension. When they were interested in stacking the boxes themselves, they seemed a little large, but the children managed. There was some confusion about the inclusion of older prototypes and why the sticks didn't fit with them.

The Teacher said she wouldn't add color and liked the natural element of the materials. Maybe some colors could be applied and taken away to address that interest? She also really liked the acrylic material and how you could see inside.

Appendix E - Trial 2 Notes

<u>Trial 2 – 04/26/2023</u>

3 Students and 1 Teacher

This time, I set up the toys before the children were brought into the room. I placed the sticks next to the box because they had difficulty getting the pieces out last time due to the tension the sticks were creating. The students were able to open and take out the pieces much easier this time.

Student 1 (Female, Age 4) immediately noticed the holes in the blocks and was looking through them. She inserted the sticks and began stacking the blocks tall with the sticks as support. After stacking them tall, she took apart her creation and began organizing the blocks horizontally and inserting the sticks on top, sticking out. When asked what she might change or what else she would want to do with this toy, she described wanting to stack the blocks diagonally (in an offset manner). One student mentioned the Velcro so she began exploring that.

Student 2 (Female, Age 5) very quietly began opening her box and thoughtfully observing it. She was immediately intrigued by the larger box and the holes in it. She used one of the larger sticks and put it through the box and started turning it. She was then interested in fitting the blocks back inside the box in different ways or stacking the blocks in different ways so that the box would fit back over it.

Student 3 (Male, Age 4) was initially interested in the toy box but slowly became uninterested and distracted by other things in the room. He immediately liked the Velcro textures and noted that it was soft on one side. He took interest in stacking the bigger boxes and making things with the lid piece. He seemed interested in collaborating with Student 1 and insisted on building near her structure. He used some blocks and the box lid to make a “tree”.