Parental Monitoring & Facilitation
for Visual-Spatial Development

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How may we assist parents in monitoring & facilitating visual-spatial development of children (3-5 years)?
Research Landscape

- Parental Insights/ Familial Trends
- Existing Constructives’ Market
- Toy Trends
- Visual-Spatial Ability/STEM
- Social Learning/ Mirror Neurons
- Block Play
- Opportunity Gaps
- Constructive Human Factors
- Preschooler Content Consumption
- 3rd Party Partnerships
- Children’s Use of Screens
- Product Benchmarking
- Augmented Reality
- Monitors
- Projectors
- Child Development
- Toy Trends
- Preschooler Content Consumption
- Existing Constructives’ Attributes
- Consumer
- Technology
- Business
- Literature
• Semi-Structured Interviews  (N=30 parents with young children)

• Contextual Inquiry

• Secondary Research (journal articles, books, and websites)
Parents generally reported stress, fatigue, and potential guilt.

They expressed the need to monitor their child’s development and be notified of red flags.
From user research, multiple categories emerged, including learning, stress, and developmental tracking motivations by parents. Parents expressed the desire to have peace of mind in knowing about their child’s development and learning progression.

Within a day in a life, parents (particularly those working) reported limited opportunities for quality time with their child. Time was often only available during evenings. Additionally, themes of fatigue and stress again appeared. Parents often expressed thoughts of concern for their child during the day while separated, being at work with the child at daycare.
Parents with young children (N=30)

RAISE SUCCESSFUL CHILD

- Guilt
- Self-worth
- Wasted time
- Confidence
- Being there
- Never doing enough
- Copy problem solving
everything
- Maturity
- Flurry of productive
- Age
- Independent play
- Smart
- Appropriate preparation
- Family life
- Help in school & beyond
- Accomplishments
- Skills
- Contribution

Motivations to Track Development

- Peace of mind
- Presence ("Being there")
- Sharing progression with interested family & friends

Stressors

- Limited time with child
- Guilt
- Ensuring proper child development
- Financial/Work, Fatigue, Social Pressures

"I feel internal and external pressure, because of the guilt for working and traditional expectations."

"I feel like I am never doing enough."

Learning Opportunities

- Social modeling (imitation)
- Few procedural educational toys
- Need for dynamic (growing), tailored content

"There is so much wasted time during the day, like for errands, when they could be learning instead."

"They are always copying everything they see us do or on tv."

Converging Themes

Content Analysis/Quotes

"Being there is important. Seeing recordings feels disconnected and not special."

"You want to make sure you’re raising a smart, successful child."

Parental guilt and stressors are significant concerns for parents raising young children. These challenges include balancing work and family life, ensuring proper child development, and feeling pressure to always be present and doing enough.

"I feel internal and external pressure, because of the guilt for working and traditional expectations."

"I feel like I am never doing enough."

"There is so much wasted time during the day, like for errands, when they could be learning instead."

"They are always copying everything they see us do or on tv."
Given axes of Pragmatism and Proactivity, an area of opportunity appeared within the “Drone” category. These parents are extremely practical, with limited time due to work responsibilities, while also possessing a strong need for work/family balance and awareness of their child’s developmental progression. To accomplish this, they are proactive and open to leveraging technology, empowering them to spend quality time with their child and have peace of mind.
Summary - User Research

- Limited time/Parent-Child interaction
- Parental fatigue, stress, & guilt
- Peace of mind/Tracking
- Desire for successful life for child
- Practicality & Sentimentality
- Parent-Child behavioral imitation
research | literature
**Child Developmental Theories**

- **Piaget Cognitive Stages**
  - Children all passing through same stages during roughly same ages
  - Sensorimotor (0-2)
  - Pre-Operational (2-7)
  - Concrete Operations (7-11)
  - Formal Operations (11+)

- **Vygosty Cognitive Theory**
  - Development varies culturally
  - No stages
  - Stems from social interaction
  - Parents as change agents
  - Development with scaffolded, assisted learning to fully internalized independent proficiency

- **Bandura's Social Learning**
  - Children are active, thinking beings
  - Natural imitation without reinforcement
  - eg. Bobo doll study

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(Shaffer & Kipp, 2013)
Social Learning - Mirror Neurons

- Grounded in interaction with others & sensorimotor learning
- Links perception & motor performance of actions
- Critical towards imitation
- Fire with observation & performance
- After observing other’s actions:
  - “Online” execution (actually doing)
  - “Off-line” internal simulation

(Oberman, et al., 2005; Williams et al., 2001; Heyes, 2009; Kosonogov, 2012; Tanaka, & Inui, 2002; Carvalho, et al., 2013)

(Social Learning - Mirror Neurons)

Social Learning Timeline

- Birth
- 6 mo
- 1 yr
- 18 mo
- 2 yr
- 3 yr
- 4 yr
- 5 yr

- Single imitation
- Multistep imitation
- Pictured objects equated to actual objects
- Able to initiate skilled behavior
- Equal efficacy of live vs. video demonstrations

(Social Learning Timeline)

(California Department of Education, 2017)
Emerging Conceptual Framework

- Social learning
- Performance
- Observation
- Concrete
- Abstract

Optimization
Visual-Spatial (V-S) Ability

“Ability to generate, retain, retrieve, and transform well-structured visual images” (Andersen, 2014)

Mental Transformations
Rotation, scaling, cutting, folding

Perspective-Taking/ Spatial Orientation
Changing one’s perspective relative to objects, awareness of relative positional changes amongst objects, magnitude/speed of displacement, integration of environmental spatial information

Facilitated by:
• Concrete (physical manipulation) - Improves Performance
• Abstract (observe demonstrations) - Improves Learning Transfer
Importance of Concrete & Abstract Media

“Using physical materials in...learning...might change the nature of the knowledge gained relative to that gained through interacting with virtual materials.... Three-dimensional forms might be perceived and understood more readily through haptic and proprioceptive perception of tangible representations than through visual representations alone.... Manipulation of concrete physical objects in supporting and developing thinking, particularly in young children... Concrete and abstract representations can both be of benefit to learning... While using concrete rather than abstract materials can often lead to improved task performance, using abstract materials can result in better learning transfer.”

(From: Marshall, 2007)

V-S Spatial Developmental Timeline

(DeCortin, 2015; Newcombe & Frick, 2010; Platas, 2017)
An area of opportunity appeared within the span between the ages of 3 and 5 years. During this time, children are developing spatial orientation and perspective-taking, while also being able to socially model multi-step behavior via demonstrations on screens. This is possible as limited screen use is allowed for children two years or older.

(California Department of Education, 2017; DeCortin, 2015; Kleeman, 2011; Newcombe & Frick, 2010; Plotin, 2017; Rosich, 2013)
- Building structures encourages a child to test spatial relationships and mentally rotate objects in the mind's eye
- Positive correlation with improved spatial development

- **Declarative & Procedural Knowledge:**
  - **Declarative** ("What?")
    - Facts & Data
    - "This is square."
  - **Procedural** ("How?")
    - Process & Routines
    - "How to rotate a square."

(Dewar, 2016; Eisenberg, 1999; Jirout & Newcombe, 2015; Casey et al., 2008; DeCortin, 2015; Dewey, 2017; Martin, 2027)
Stages of Block Play

1. Exploring (1-3 years)
   Blocks teted, carried, felt, moved, held, dropped, packed, and re-packed, Little to no building, Block attribute exploration (size, shape, texture, weight, fit)

2. Building Begins (2-4 years)
   Creating horizontal rows and/or vertical tower stacks, typically with much repetition. Some imaginative play through use of basic use of prop accessories, Use of pattern cards

3. Bridging (3-4 years)
   Creating bridge or passage-way, Learn trial and error, balance, May use task cards featuring images of bridges and/or blue cloths to represent water

4. Enclosures (4 years)
   Horizontally enclosing space then vertically stacking.
   Planning: Problem solving, Scenarios/Props, Learn inside, outside, perimeter, boundary, May use task cards

5. Complex Structures (4-5 years)
   More elaborate/decorative designs with multiple levels, curves, patterns, symmetry, balance, patterning, sorting, matching, & accessories (as above); Cooperative play, Use of variable part size and types

6. Represent. Structures (5 years+)
   Structures and their functions named; Dramatic play with scenarios; Correspondence with realistic, familiar objects/contexts in child’s life; Cooperative play, Prior Planning


Foundational Aspect of Block Play

Existing Early “Constructives”

Reflective in Later Professions:
- Sculpting/Rapid Prototyping (clay/foam)
- Sketch/CAD foundational approaches (eg. box)

Introduce Concepts of:
- Part/Whole (eg. cylinder within cube)
- Counting
- Relative Proportion
- Fit/Joinery
Visual-Spatial Skills
• Imagery (sizes, shapes, colors, patterns, textures)
• Transformation
• Spatial Orientation
• Perspective-Taking
• Matching, Sorting, Categorization, Stacking

Cognitive
• Problem Solving, Planning, Imagination
• Mathematics (counting, relative number & size, comparisons, whole/part, symmetry, one-to-one correspondence)
• Creativity
• Science (hypothesis testing, logic, cause and effect, gravity, weight, balance, volume/space)

Social
• Sharing
• Cooperation
• Turn-taking
• Pretend/Dramatic Play

Physical
• Active play (bending, stooping, crawling, reaching, squatting, stretching)
• Fine/Gross Motor Skills (hand-eye coordination, dexterity)

Values of Block Play

Visual-Spatial Components

INTRINSIC
• Imagery
  (Inherent object attribute comparisons, including form, color, and size)

EXTRINSIC
• Spatial Orientation
  (Objects’ relative positions)

STATIC

DYNAMIC

Transformation
  (Changing object attributes; eg. scale, rotate)

Perspective-Taking
  (Changing one’s point of view of object)

(Uttal et al., 2003)
Emerging Conceptual Framework

social learning

observation

demos + constructives

abstract

performance

visual-spatial ability

concrete
Optimized Learning

Vygotsky’s Zone of Proximal Development

Csikszentmihalyi’s Flow Model

Scaffolding: Enable child to solve a problem just beyond their abilities & as the child approaches mastery, withdraw support

Techniques: Demonstrate, Hint, Reflect, Document

- “Please tell me about what you built. What features does this have?”
- “How could we build a friend for the giraffe?”
- “How could the blocks be as tall as you?”
- “How might we span this space?”
- “How could we build the Empire State Building?”

(Mincemoyer, 2016; Nakamura & Csikszentmihalyi, 2014; Dalai Lama Center for Peace and Education, 2014)
Conceptual Framework

- Social Learning
- Procedural/Declarative Learning
- Visual-Spatial Ability

Summary - Literature Insights

- Constructives
- Social, Cognitive, & Physical Development
- Optimization
- Social Learning
- Procedural/Declarative Learning
- Visual-Spatial Ability
Global Constructive Toy Sales

- **LEGO**: 80%
- **Other**: 20%

U.S. Constructive Toy Market Share

- **LEGO**: 80%
- **Mattel/MegaBrands, Mega Bloks, Construx**: 11%
- **KNEX, Lincoln Logs, Tinker Toys**: 6%
- **Other**: 11%

(Reportlinker, 2017)

Global Constructive Toy Sales

- **LEGO**: 80%
- **Other**: 20%

(Reportlinker, 2017)
Current Toy Trends

- Collectibles
- Physically Active (in/outdoor)
- "S.T.R.E.A.M." (building blocks, stacking, puzzles, problem solving, creativity)
- Classic Low-Tech (games, puzzles, dolls)
- Tech Integration (drones, virtual pets, robots)
- Children’s Movie Licensing (LEGOs, ride-ons, plush, action figures, puzzles)

(Appell, 2017)
Existing "Dumb" & Augmented Reality Constructives

• No demos
• Not milestone-based/"growing"
• No monitoring feature
• No integrated parental interaction

Educational & Child Tracking Apps

• Primarily declarative content
• No direct demos for children
Currently, for toddlers, their primary means of content consumption continues to be through large screens, via tv, videos, and DVDs (potentially portable player). Also, many toddlers use the more traditional option of books.

Media Consumption by U.S. Children (3-5 years)

Opportunity Gaps

There are few “growing” children’s products that provide both declarative & procedural learning (nor visual-spatial) aspects.

Opportunity: Provide declarative & procedural “growing”/visual-spatial children’s products
An examination of children’s toys revealed that recommendations often for the introduction of milestone-centric toys are many times late, relative to time of milestone appearance. In actuality, earlier or on-time introduction of these toys would potentially better facilitate or kick-start such milestones.

(Duran, 2001; Petty, 2006; Centers for Disease Control and Prevention, 2016; Berk, 2006; Christakis, 2014; Breiniski, 2015; Child Development Institute, 2015; Dorrill, 2008; Drobnjack, 2016; Elizabeth, 2003; Hilton, 2014; Hoffman, 2013; Kaleidoscope Australasia, 2016; Kangoa, 2017; Kawa, 1934; Lopa, 2014; Thomasson & Page, 2013; Torres, 2015)
**Insight Translation To Design Criteria**

**Stressors**
- Limited time with child
- Guilt
- Ensuring proper child development
- Fatigue, Social Pressures

**Motivations to Track Development**
- Peace of mind
- Presence ("Being there")
- Sharing progress with interrelated family & friends

**Learning Opportunities**
- Social modeling/imitation
- Free procedural/educational toys
- Need for dynamic (growing), tailored content

**Familial Trends**
- Geographic dispersion
- Limited parent/child interaction/time
- Divorce/Separation
- Outsourced child care
- Pragmatism/Sentimentality & Pro-activity/Passivity approaches

**User (Parental)**

**Visual-Spatial**
- Visual-spatial development positive contribution towards STEM skills
- Development with concrete & abstract practice, begins immediately after birth, 2x2 matrix, Malleable, Match with skill level
- Block-play & edgess

**Learning**
- Imitation via mirror neurons
- Declarative/procedural learning
- Convergent/Divergent, Montessorian approach/Contextual
- Educational vs. Toy Myth

**Child Standards/Specifications**
- Screens for children only >2 years old
- Choking hazards for those <3 yrs old
- Child anthropometry

**Construction**

**Current Toy Trends**
- Collectibles
- Physically active
- Tech integration (drones, virtual pets, robots)
- STEM (blocks, build, stack)
- Card/Board game tech (games, puzzles, decks)
- Children’s movie licensing

**Constructives**
- Attributes
- Human Factors
- Drawbacks

**Benchmarking**
- No “monitors” facilitate and grow
- No apps with direct-to-child procedural demos
- No apps with declarative/procedural content (eg. V-S), parent-child interaction, & “smart” content presentation (progression or iteration)
- No contextually aware apps direct to child
- No TUI that facilitate, grow, are wearable, nor present "smart" content
- No milestone-inducing products/system with hardware & software companion solution, low to no STEM educational products, with "smart" child product, growing, smartphone-enabled, monitoring, nor video demos direct to child
- Constructive play items only have:
  1) Imalleable and limited fidelity parts
  2) Limited assembly options
  3) Sometimes narrow themes

**Opportunity Gaps**
- Smart-toy with both parent-child interactivity
- Smart child product that "grows with child and helps monitor"
- Provide declarative & procedural "growing" child product
- Explicitly market child product for its capability to "grow" with child in other developmental categories
- Age-specific, timely introduction of toys and associated activities

**Technology**

**Tech Trends**
- E-Learning
- Internet of Things (IoT)
- Mobility
- Augmented Reality
- 3D Scanning
- Content, delivery methods
- Educational/Developmental tracking apps

**Learning**
- Imitation via mirror neurons
- Declarative/procedural learning
- Convergent/Divergent, Montessorian approach/Contextual
- Educational vs. Toy Myth

**Business**

**Personal Finance**
- Dual parented, employment
- Work travel
- Financial strain

**Constructives**
- Attributes
- Human Factors
- Drawbacks

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Concept Core Aspects

V-S, Physical, Cognitive, & Social Developmental Monitoring

Edification in Visual-Spatial Ability & Foundational Building

Facilitation (Via Play with Constructives & Social Modeled Demos)

Declarative & Procedural Content

Personalized, Optimized Growth

Design Criteria

Primary Criteria

Parental Monitoring/Selective Interaction

Developmental Facilitation

Growing

Mobile

Sharing-Enabled

Tech-Enabled (Smart, System)
Safety Considerations

- Choking
- Suffocation
- Burns
- Falling
- Pinching
- Excessive Screen-Time
- Abrasions, Lacerations, Splinters
- Drowning
- Electrocution
In order to make the design criteria actionable, different modalities were considered. For example, content delivery may have been accomplished via screens or projectors. Similarly, other modalities were considered for each requisite function.
ideation | exploration

Exploration

- Constructives with storage
- Demo/content delivery
- Cards for tracking
- Smart/Connected
• Rectilinear (similar to building blocks)
• Totable, home use
• Playful use steps

• Bulk storage
• Playful use steps
• Integrated mat
• Screen/Projection
Advantages, disadvantages, and any unique qualities were assessed for various concepts. This allowed for potential positive features to be pursued in a later iteration, while avoiding possible pitfalls.
Simple Constructive Storage - Existing Modalities

- Hard vs. Soft
- Rectilinear vs. Curvilinear
- Handle vs. Non-Handled

Box/Container
(wood, plastic, canvas)

Sack/Bag
(cloth, canvas, plastic)

Pail

Cylinder/Tube

Hinged Briefcase/Lunch Pail

Existing Constructive Storage Dimensions

In order to accommodate the smallest potential user within this age span (5th percentile 3 year olds), relatively large bins could only be gripped, lifted, and carried given special features, such as recesses, cut-outs, drafts, curvature, and texture, due to limited chest breadth.
Prototyping

“window” grip

Card slot, pop-up, & buttons

“ledge” grip

Integrated mats
ideation | semantics

Semantics - Moodboard

- Soft curvature
- Color-coding
- Playfullness
- Inner/Outer visibility
- Bulky forms
- "Transformer"-like
### Semantic Product Space

<table>
<thead>
<tr>
<th>Constructive Toy</th>
<th>Content Delivery Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Features</strong></td>
<td><strong>Materials</strong></td>
</tr>
<tr>
<td>playful</td>
<td>color-coded</td>
</tr>
<tr>
<td>chunky</td>
<td>soft curvature</td>
</tr>
<tr>
<td>smart</td>
<td>durable</td>
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<td>manipulative</td>
<td>lightweight</td>
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<td>mobility</td>
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<tr>
<td>experiential</td>
<td>growing</td>
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<tr>
<td>classic</td>
<td>customizble</td>
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<tr>
<td>simple</td>
<td>connected</td>
</tr>
<tr>
<td>active</td>
<td>collectible</td>
</tr>
<tr>
<td>challenging</td>
<td>connected</td>
</tr>
<tr>
<td>articulated</td>
<td>rechargeable/ removable</td>
</tr>
</tbody>
</table>

### PMI (Plus, Minus, Interesting)

- Translucent side windows for visibility of content & grip (inner/outer visibility)
- Playful use steps
- Integrated mat
- "Stud" multifunctionality (projection/storage)
- Simple color-coding
- "Transformer-like"
- Bulky, blocky
Concept with Feature Inspiration

- Translucent side windows
- Totable size and grips provided
- Channeled rear facet for mat storage
- “Pop-up” multi-functional “stud” (projection, card storage)
- Inset inclined display
- Patterned mat for digitizing & embellishing builds by parent and child with proprietary app
- Collectible cards with associated demo builds or declarative content
- Smart connectivity with parents’ devices, enabling tracking & facilitating child’s progression
Form Must-Haves Revisited

content delivery (demos)

constructive storage

optimization/growth

playfulness

trend leveraging

tracking-enabled

System Overview with Must-Haves

content delivery

constructive storage

optimization

tracking

Cooperative Parental-Child Build Embellishment

Parents’ Smart Devices with App

Collectible Cards (prompts, challenges, themes)

Constructive Toy (Proprietary or 3rd Party)

trend leveraging

playfulness
The child selected a collectible task card, with a particular illustrated task, inserts card in slot, and views a facilitatory demo. Then the child models this behavior by completing a similar build. The parent may then assess if the child has mastered this level of difficulty and may progress further or conversely, if the child should repeat the task. Also parents may then scan the build with their device, which will digitize the build, allowing for further embellishment, such as adding more details that could not be done with the concrete constructives.
Final Concept | Smart Tote
When the rear flap is lifted, the middle stud pops up, allowing the child access to both the stored cards within the stud and to the foam mat in the tote’s rear, which may be removed from the dual vertical channels.

The mat would be unfolded, with the patterned side facing upwards. The child may select a card with a particular task and specified difficulty level. After the constructives are then dumped out onto the mat from the tote’s rear, the child may complete the build. When finished, the parent may then scan & digitize the build. This “digi-build” may then be further embellished with the child, via a smart device, offering an opportunity for quality parent-child interaction.
Features (cont.)

Mat Stored in Dual Vertical Channels

Inclined Inset Display

Step-by-Step Use

1

2

3

4
Step-by-Step Use (cont.)

5

6
Example Prospective Card

Design a Zoo

Categories facilitated

Readable code

Task difficulty level

Rough task visualization

Task description
Proprietary Constructive

- Unit-Cube
- Part/Whole relationship
- Counting
- Primitive Forms
- Subtraction & Addition

final concept | constructive
Major App Features*

*See video demo of app on USB drive in back

Example Scenario - "Design a Zoo"

Parent and child spend day at the zoo
They visit the zoo gift shop
A collectible card deck is purchased for use with the "raise" smart tote
Parent scans in deck, unlocking access to new tasks in the app's library

Parent provides cards to child within skill level. Child selects "Design a Zoo" card and inserts in reader to watch demo
Child completes build and then informs parent
Parent assesses task for successful completion, and then scans the build, digitizing it for further embellishment
Parent and child flesh out virtual "digi-build" with a mobile device, such as adding animals and zookeepers
References


References (cont.)


Treadwell, T. (2017). Group Psychotherapy, Cognitive Behavioral Therapy, & Psychotrauma: From courses/psy201c/201c(course/201c_theory)="broul/psyc201c/201c_theory"


thank you!