More Interactivity is Better

A White Paper on the Digital Redesign of Children's Toys

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Humbly submitted on: 5/3/02

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Abstract

Mohr's Law predicts as the price of Integrated Circuits drops, toy manufactures will add this powerful element into toys.[1] Many mothers question whether the super powered toys have any value added compared to their traditional counterparts. Is the new generation of toys really smarter? To answer this question, one must examine how children interface with their surroundings. Other constraints in the toy market such as cost, safety concerns, and even battery life cannot be ignored. As the underlying technology increases from passive to wind-up to analog to digital toys, features can be added that engage children. Several toys such as LeapPad, by LeapFrog, that are currently on the market are excellent examples. Toy designers must strive to make smart toys "over achievers" by utilizing the power of the IC and understanding children.

[1] http://www.cyberwalker.net/features/kids-tech-toys.shtml

How Children Interact with Surroundings?

From passive toys to toys with huge processors, at the heart is a concept that engages the interests of children. Overwhelming change happens in children from birth to three years. Around the age of ten, children stop playing with traditional toys such as dolls, building sets, and action figures. For these reasons, this paper divides toys into two categories: "Children's Toys,"[2] and "Pre-School Toys." The categories below divide a child's world into the five senses and the cognitive world. (For a more complete listing of the development of children please see appendix 2.)

- **Visual**

Children under the age of one are immobile, and need to look around to receive information. Therefore, visual effects are the primary means for pre-school toys to grab a child's attention. From spinning colors, to blinking lights, to LCD screens, toys can offer a variety of stimuli to children. Visual effects also provide an immediate and grand cause effect response. If a button is depressed and released, the action can instantly understood by a young child, and easily reproduced.

As children grow, they interact more with their environment. Children's toys can use visual effects to teach. Different colors on blocks show patterns. Lights can illuminate answers behind a screen, and an LCD screen can display sentences for children to practice reading. In both cases, children will perform a task to receive a visual payoff.

- **Aural and Speech**

As with the visual effects, auditory effects are often used in toys; the payoff is grand and immediate. The options available range from mechanical clickers, bells, whistles, to speakers that play voice quality sound.

Sound encourages children to a new level of interaction. A farm toy that imitates farm animals teaches children the farm animal noises, and encourages them to imitate the noises. Children begin to speak around one year, and researchers have found that speaking around

children helps form the proper sounds for consonants and vowels. A toy that plays music invites children to dance to their favorite songs.

- **Tactile and Motor Skills**

Many toys are made from plastic. The same plastic can either be soft or hard depending on the radius, part design, and the quality of the mold. Flash, or thin plastic around the part's edge, can cut children's fingers. Some plastics are very soft with shore hardness A of less than 40. Low durometer PVC, EVA's, and injection grade rubbers can encourage children to explore a toy by touch.

Softgoods, or fabrics, are often incorporated into toys. Many times, mechanisms are put inside a softgoods shell. One example is the Tickle Me Elmo doll. As a child tickles the doll, the doll will laugh and vibrate.

Motor Skills increase exponentially for children. At birth they cannot support the weight of their head, and by the age of 18 months, they can walk. At three, they can jump 2-3 feet. At five, a child can throw kick and catch balls. It is a similar type of development for fine motor skills. At 6 months, a child learns to pinch their thumb and index finger together. At five a child can write. A child can become frustrated with a toy that is too difficult to master. It is important to understand the capabilities of children. Human factors are a key element in toy designs.

- **Smell and Mouth**

Many pre-school toys are developed with the intention that children with teeth the toy. It is important to avoid materials that are too soft. They can break off into small parts and be choking hazards. It is also important that battery compartments are well sealed so children cannot teeth them. They are a choking hazard, and a corrosive material.

- **Emotional Interaction**

Many toys have a human style that makes the child feel attached to the toy. A toy can take on a personality and the child can feel emotionally attached to the toy. Fisher-Price

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[2] Please see the definitions page for any words in quotes.

produced a train called Toots that had a talking face with a moving mouth. There were reports where children sleep with the train engine Toots.

It is not until a child is three years old, where a child will play with other children. Before this time, the children are merely playing along side the other children at the same playset. Toys help children interact in a social environment. They teach sharing and encourage role play.

Factors to consider for Toy Design

How children's interaction is the underlying fundamental in any toy, but toys, like any other consumer good, have other factors involved for design.

- **Safety and Liability**

Babies are very fragile, and after cars, the Baby Crib is the most regulated item in US markets. Every country or region has its own unique set of standards, and it is the manufacturer's responsibility to be compliant with the standards. Europe has EN standards, the US has the ASTM, Canada has the CSA, and Australia has the AS. Many times, the international standards are the same, but they can be slightly different. Pre-school toys must maintain this high level of standards.

One example of a safety standard is the mandate of no loose small parts for toys intended for children under three years old.[3] (Packages for children over three with small parts will have a warning stating: "Contains small parts, not intended for children under three.") If a product for a child under three does have small parts (or parts that become small parts due to breakage), the CPSC, (Children's Products Safety Commission), will issue a recall on this product. Recalls are both costly and they damage a company's reputation. A company must remove all harmful product from retail store shelves and either alter or scrap the product, and the company must make efforts to fix or reclaim all products that have already been purchased.

Although many of the safety issues mandated by law do not apply to children greater than three years old, safety is still extremely important to consider in toy design. A toy manufacturer is liable until a child is fully matured. A five year old child who is blinded by a sharp edged toy can sue until the age of twenty, or fifteen years later. Special care must be made when developing new and innovative products so they account for unseen risks.

[3] ASTM standard can be purchased from- http://www.techstreet.com/info/astm.html

- **Cost**

The toy budget is approximately $250 per child in the United States, and the total market is 8 billion dollars.[4] It is the goal of most parents to spend the budget with several smaller purchases and a few larger purchases. Hence, the maximum price parents want to spend on a toy is around $65. (Obviously, $65 is a rule of thumb considering the cost of a motorized ride on vehicle is $250, and this market is $200 million in the US.) With the limited budget it is important to consider the price vs. the value of the toy.

Of the $65 dollars a consumer would spend on a product, how much is actual product? After retail profit, corporate profit, shipping and packaging costs are removed, the amount the actual product is worth in raw goods and labor is only $24 dollars, or around 40% of the purchase price.[5] A decent estimate for labor costs is one half of the total raw cost is labor. Hence, the final amount a company has to spend on raw material for a $65 dollar item is $12, or around 20%.

(See appendix 2 for a table on the price of several important elements in a product.)

- **Battery Life**

Batteries are the solution for power in electronic toys. High voltage and high current wall outlets can be extremely dangerous for a child, and are rarely used. IC's draw around 150 mA. LED's draw around 40 mA per bulb, but many times the duty cycle is only half or less. Sound varies with the volume, but is around 200 mA at around 80 dB.[6] With AA alkaline batteries, a toy will run for 20 plus hours. Carbon Zinc is lower grade of batteries, and will run a toy for 6-7 hours.

Higher current draws affect battery life significantly. It causes batteries to overheat. DC Motors can draw upwards of 1.5 Amps. AA alkaline batteries will run a toy with a motor for only seven hours. This is around a third of the life. Carbon Zinc AA wil only run for 1.8 hour. C cell batteries will improve the performance 3 times longer for motor performance, but at the cost of a bulky size.

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[4] http://www.oxfam.org.uk/policy/papers/queens/queens2.htm

[5] Corporate profit approx. 40%, retail profit approx. 30%, shipping and packaging approx. ¼ product cost.

Progression of Complexity

Taking into considering children factors and toy industry factors, the value added by adding complexity to a toy can be examined. How can the digital redesign take advantage of the skills of children? Consider a toy car that sells for $20 as it progresses up the ladder of complexity from "passive toys" to toys with an integrated circuit. There is $4.00 of raw material in this car, and as parts a swapped out for other features, how does this effect the end consumer?

- **Passive Toys**

Passive toys have a long rich history. Because money is not being spent on other components, they appear study, well built, and tuff. For centuries, the toys were built without electronics because of a lack of technology and there are many methods to reproduce noises. Clickers are Mylar sheets that snap against a surface. This could make a turning axle sound like a motor cycle. Voices are metal leaf springs that contact ridges on a spinning axle. Depending on the pattern and depth of the ridges, a truck could sound like it has a diesel engine.

The epitome of a passive car is the Tonka dump truck by Hasbro, (pictured above).[7] This item sells for $17.99 and has a foot long metal dump bed. On the amazon site listed below, there are rave reviews how this truck is a "classic" toy. Some people even claim that it is educational, saying it merits five out of five stars in that category.

The drawback to this group of toys is even with all the bells and whistles attached, it only has bells and whistles attached. The advantage is that the saved money can produce a strong, value added toy. As children are bombarded with media, many will ask the proverbial question, "What does this toy do?"

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[6] 80 dB is used often because Australia demands a maximum of 85 dB.
[7] http://www.amazon.com/exec/obidos/tg/stores/detail/-/toys/B00000IWAR/qid=1053031101/sr=2-1/ref=sr_2_1/002-8507249-3811253

- **Wind-up/ Stored Energy**

Many toys use springs, back wind motors, air pressure, and flywheels to store energy. The energy can be released at a different rate, or redirected to create a surprise effect.

Super Soaker by Hasbro is an excellent example of stored energy. A child pumps air into a chamber and the pressurized water can shoot with large volumes and great distances. Traditional squirt guns cannot compete with a child armed with Super Soaker EES 2000. It should be of note, that "kid power" out powers a DC motor running on 6 Volts, but the toy must be tested with children so they understand how to activate the toy, and the forces required are appropriate. For example, children are very poor at loading parts together where the snaps are not on the visual surfaces of the parts.

A simple stored energy car is a wind-up car. A back wind motor involves a plunger, a large spring, and a gear train. The large spring costs around $.15 It is just an expensive to add a back wind motor, and the performance is not as consistent as motor driven cars. For this reason, a $20 wind-up car does not exist on the market today. In conclusion, stored energy features are common, but not a mainstream feature for all toys.

- **Electronic Toys**

Practically all-electronic toys on the market today have IC's or digital logic gates because the price for large run, low memory IC's is very low. An IC with 32 K memory is only 16 cents. That is more than enough computing power to blink LED's and control the switching on a simple toy.

Motors are noisy electrically due to back EMF, and they draw enough current easy burn out an IC. Any time a DC motor is used, the motor must be isolated from the IC. Many times this involves a high power transistors and capacitors and resistors that dissipate the back EMF. The transistors bypass the IC and draw current directly from the batteries.

- **Toys with IC's**

There are countless reasons for using IC's in toys. Without taking children into consideration, two reasons are cost and ease of design. Considering children, IC's can deliver exactly what the imagination with ingenuity can demand. Shown at the right is Kasey the Kinderbot by Fisher-Price. It has three gearboxes, a LCD screen, four-megabit processor, and exchangeable ROM packs. All these systems combined form a robot friend that helps kids to learn. Some categories include tagging techniques, sounds, and complex mechanism control.

IC's rely on software for control, and software is easier than a mechanical or electrical system. Altering a variable in the software can make most changes. Consider a blinking LED. An electrical system would use a capacitor and resistor to accomplish this, while an IC would pulse an IO line. If the system would change in development, the resister would have to be recalculated, while a software change would be done in seconds. Yet, if the system would change in production, the old IC would have to be scrapped at a loss, to implement the change, while the circuit could be reconfigured. Hence, custom IC's cannot be changed once the are produced, and there is at least a lead-time of four weeks. Despite this, IC's are still cheaper and more powerful than electronics, because larger changes would call for a complete redesign of the electronic circuit.

Through inputs, IC's can sense the world around them. If the inputs are separate play pieces and specifically identify the piece, the IC can react appropriately. This tagging technique can make inanimate objects have character, and draw a emotional response from children. Switches connected to the IC are a great means of tagging because of low cost, and the separate pieces.

Consider a set of cars with a key. The key is plugged into the base station, and the station knows which car is being operated. With switches, the object must always be connected to the base. The car example is not very robust because once the child loses the key, (and they will), the car can no longer communicate with the base station.

Another tagging technique is Clicker Technology. A clicker, clicks a digital signal similar to Morse code. The IC deciphers the code, and responds accordingly. The range is around 5 feet, or the distance the microphone can hear the clicker signal.

IR and RF signals are also excellent, robust methods. Both forms of tagging can be purchased as custom and off the shelf parts. One draw back is they require electronics and batteries in both units. The cost vs. quality for the toy must be considered. Again, a little ingenuity can make a sensor that is cost effective robust enough for toys.

With the cost of memory always decreasing, an IC can be compared to a digital jukebox. Speech is also possible with IC's. By storing words and phrases in separate memory banks, sentences can be assembled. "Hello, let's go to the park," can easily be changed to, "Hello, let's go to the science class." Voice inflection in sentences can change meanings of words, and the exact phrases must be altered to fit the intention.

Complex mechanisms are common in toys. Consider an RF car with a tank style driving. The car can spin on a dime and if fun for a child. In order to drive forward, the left motor and the right motor move forward. To turn the motors move in opposite directions. For a child to commandeer, the vehicle they would have to control the direction of motors in a traditional system. The IC can interpret turn left and turn right and handle the direction of the motors. Also, going away and coming back changes the direction of left and right. With two IR receivers, the car will sense which direction the car is going and will change orientation for the child.

What does the Future Hold?

As stated before, from passive toys to toys with huge processors, at the heart is a concept that engages the interests of children. Children are unique in their abilities, likes and dislikes. Toys are a consumer good, and they have to make money, perform up to a consumer's expectations, and be safe. The best toys can take all the forces involved and compile a great toy.

The beauty of the IC is that they can readily implement any idea a person can imagine. Sensors can detect motion, and memory can hold thousands of words. The motors and mechanisms can be easily be activated and controlled. With ingenuity such as the Clicker Technology, cost can be controlled.

Appendix 1: Developmental Milestones

Developmental Milestones*

0 to 3 Months

Physical

- lifts head in prone
- tracks with eyes
- briefly grasps
- glances at people
- holds head steady
- bear weight on legs
- turns head sideways in supine
- extends both legs
- rolls side to supine
- kicks reciprocally
- blinks at sudden stimuli
- regards colorful objects
- moves arms symmetrically
- activates arms on sight of toy
- improved head control

Social/Emotional

- returns smiles
- learns trust
- shows emotions
- recognizes caregiver
- regards face
- regards own hand
- establishes eye contact
- brings hand to mouth

Language

- vocalizes response
- makes throaty gurgles
- sounds vary in pitch
- vowel-like vocal sound
- responds to loudness
- laugh, squeals & coos

Cognitive

- prefers patterns
- watches own hands
- reaches for hanging objects
- explores with eyes
- looks at objects
- listens to sounds
- responds to texture on face

***The *Developmental Milestones* were compiled from various child development charts and references and edited by the Fisher-Price Child Research Staff. Because children develop at their own individual pace, the *Developmental Milestones* should be referred to as general guidelines rather than as precise time frames.**

Developmental Milestones

3 to 6 Months

Physical

- reaches & grasps
- rolls prone to supine
- transfers objects
- kicks while prone
- bear weight on legs
- chest up arm support in prone
- head steady in supported sitting
- sits supported
- pull to sit – no head lag
- hold & examine object
- uses both hands
- looks from one object to another
- eyes follow moving object 180
- clasps hands
- grasps toys actively
- reaches w/both hands
- swallows strained or pureed food
- uses tongue to move food
- better head control

Social/Emotional

- mutual gazing
- anticipates comfort
- initiates interaction
- gestures likes/dislikes
- recognizes mother visually
- discriminates strangers
- socializes w/strangers
- demands social attention
- enjoys social play
- enjoys frolic play
- repeats enjoyable activity
- makes approach to mirror
- reaches to familiar person

Language

- responds to rhythm
- responds to speech & facial expressions
- responds to expression of emotions
- imitates speech sound
- responds to rattles
- combines syllables
- jabbers
- blinks to threat
- vocalizes in response to adult talk and smile

Cognitive

- explores things orally
- explores things with hands
- likes different textures
- visually attracted to people over objects
- makes noise w/objects
- sees clearly across room
- searches for partially hidden object
- anticipates reappearance of object
- grasps 2 objects at the same time
- visually follows a fallen object
- imitates action (claps)
- turns head towards sound

Developmental Milestones

6 to 9 Months

Physical

- sits w/out support
- crawls backward/forward
- stands with support
- pull to stand
- uses pincer grip
- reaches w/one hand
- demonstrates balance
- lifts head & assists to sitting
- holds weight on 1 hand in prone
- holds head erect when leaning forward
- rolls supine to prone
- bites food voluntarily
- bites and chews toys
- drools less
- holds own bottle
- drinks from cup when assisted
- holds spoon

Social/Emotional

- plays peek-a-boo
- responds to mirror
- likes praise
- feeds self crackers
- initially shy w/stranger
- plays patty cake
- wave bye bye
- indicate wants
- distinguishes self
- shows separation anxiety
- cooperates in games
- shows fear of unfamiliar
- knows family members
- may respond to name
- mouthing of objects
- reacts to strangers

Language

- vocalize to toys/mirror
- early word recognition
- babbles vowel & consonant sounds
- recognizes names of people and things
- make work/like sounds
- repetitive string of sounds, i.e. babababa
- inflections in babbling
- cries to elicit help

Cognitive

- understands in & out
- begins pointing
- performs action to get a result, (pull string on talking doll)
- uncovers object hidden by cloth
- moves to retrieve dropped object

Developmental Milestones

9 to 12 Months

Physical

- puts object in box
- rolls or push objects
- begins to cruise/walk
- crawls up stairs
- clasps hands
- hands object to others
- get to sitting
- lowers to sitting from standing
- goes from sitting to prone
- increased balance
- stands momentarily
- walks with both hands held
- pokes with index finger
- takes objects out of container
- finger feeds self
- holds spoon
- cooperates with dressing by extending arm/leg

Social/Emotional

- drinks from cup
- indicates wants
- has likes/dislikes
- does action for praise
- recognizes others
- plays with family members
- extends toy to show others
- begins imitative play
- explores environment
- gives affection
- imitates waving bye-bye

Language

- vocalizes to rhythms
- double consonants, i.e. da-da, ma-ma
- looks at picture books
- moves to rhythm
- interacts w/people
- 1 word sentences
- point to desired object
- point to named object
- understand simple commands
- claps hands when asked
- imitates simple sounds

Cognitive

- puts down object for another
- explores object in many ways, touch, taste, smell
- knows objects have front and back
- hits 2 objects together
- imitates scribbling
- reacts to “NO-NO”
- stacks & unstacks rings
- looks at pictures in books

Developmental Milestones

12 to 18 Months

Physical

- throws objects forward
- stack/balance 2-4 blocks
- pushes while walks
- scribbles
- stoop and recover
- walks successfully
- walks backwards/sideways
- goes up stairs
- puts objects into box
- dumps objects out of box
- uses spoon & fork
- balances kneeling/standing
- stands from supine
- stands on 1 foot w/help
- bends over & looks through legs
- carries toy while walking
- uses both hands in mid-line
- places 1-6 pegs in pegboard
- holds & drinks from cup

Social/Emotional

- likes routines
- begins to imitate
- begins to undress self
- hugs/kisses parents
- separation anxiety
- enjoys attention
- displays independence
- occasional tantrums
- helps in house
- feeds doll
- gives toy to familiar adult
- follows simple directions
- understands “NO”
- frequent temper tantrums
- show sense of humor
- laughs at incongruities
- imitates adult behaviors
- play ball cooperatively
- shows toy preferences

Language

- 2-6 word sentences, i.e. me spoon/mom ball
- imitates words
- uses inflections
- makes requests
- responds to voices
- identifies a facial part
- follows 2 step direction
- meaningful use of word “no”
- 5-10 word repertoire
- intonation of voice

Cognitive

- trial/error approach
- uses object to reach another
- finds hidden object
- imitates gestures
- use object many ways
- imitates household routines
- removes small object from container
- recognizes familiar people
- points to indicate needs/objects
- points to familiar picture when asked
- simple problem-solving

Developmental Milestones

18 – 24 Months

Physical

- turns knobs
- begins to run
- kicks ball forward
- backs into small chair or slides onto it sideways
- squats in play
- imitates vertical, circular, horizontal scribble strokes
- folds paper not precisely
- can string 1 inch bead
- goes up/down stairs
- jumps with both feet
- stack/balance 4-6 blocks
- plays with food
- unzips/zips large zippers
- puts on shoes

Social/Emotional

- displays emotions
- helps with tasks
- identifies body parts
- likes solitary play, i.e. colors, builds, books
- brush teeth w/help
- wash & dry hands
- expresses affection
- desires control of others
- easily frustrated
- interacts w/gestures
- engages in parallel play
- enjoys solitary play
- enjoy rough & tumble play
- sense of self-importance
- longer play periods
- shows signs jealousy

Language

- imitates phrases
- gives own name
- uses about 20 words
- sits through story
- identifies parts of body
- identifies clothing
- knows 50+ words
- knows words: me/you
- combines words
- points to pictures
- speech ½ understandable
- uses simple 2 word phrases
- expresses wants w/"more"

Cognitive

- climbs on chair to get something
- moves around an obstacle to get object
- use toys appropriately
- imitates actions

Developmental Milestones

2 Years

Physical

- rides trike
- favors one hand
- climbs
- stack/balance 8-9 blocks
- throws ball overhand
- does 2-hand activity
- jumps backwards/sideways
- jumps forward up to 2
- walks on tip toes
- balance 1-2 seconds on each foot
- imitate vertical line
- catches large ball
- walks with legs close together
- holds pencil like adults
- begins to draw (designs/forms)
- snips on line using scissors
- folds paper in half
- strings ½ inch beads
- makes sharp turns when running
- runs on toes
- avoids obstacles on path

Social/Emotional

- shows independence
- interest in toileting
- inquisitive
- gender awareness
- likes routines/rituals
- pride in achievements
- separation is easier
- imaginary characters, i.e. monsters, friends
- emerging imagination
- names a friend
- dramatizes using a doll
- contrasts self w/others
- shy w/strangers
- says no but submits
- frustration tantrums peak
- likes 1-on-1 w/adults
- uses word “mine”
- extreme emotional shifts
- has difficulty w/transitions
- resists help
- plays interactive games

Language

- makes words plural
- 3-4 word sentences
- generalizes objects
- names familiar objects
- follows complex directions
- asks what/where/when
- knows some adjectives
- knows some colors
- speech understandable
- has conversations
- includes prepositions
- talks w/loud voice
- says first name
- answers simple questions

Cognitive

- understands shape and color categories
- begins understanding size(graduated blocks)
- begins understanding spatial relationships
- begins awareness of quantity
- begins to match similar objects
- categorizes objects, blue, red, square
- begins understanding part/whole relationship
- likes simple puzzles
- knows big/little
- sorts shapes
- tells first & last names
- enjoys sand & water
- matches familiar objects
- follow simple 3-part directions

Developmental Milestones

3 Years

Physical

- cuts and pastes
- ties a knot
- strings large beads
- scribbles/draws
- hops on 1 foot
- balance 2-3 seconds on foot
- thumb wiggle
- copies o and +
- can draw a person
- catches 8 inch ball
- jumps distance between 2-3 feet
- shows hand preference
- verbalizes toileting needs

Social/Emotional

- curious about babies
- has common fears, i.e. animals, creatures
- bathes/dresses self
- plays in groups
- vivid imagination
- brushes teeth
- prepares cereal
- plays board/card games
- begins to obey & respect rules
- knows own gender
- relates experiences

Language

- asks why/how
- says first/last name
- identifies body parts
- recites rhymes/songs
- understands prepositions
- uses full sentences

Cognitive

- makes comparisons
- finishes partly completed pictures
- make up stories
- simple counting
- identifies colors
- knows own age
- understands simple concepts

Developmental Milestones

4 Years

Physical

- hops on 1 foot without support
- skips or makes running jumps
- good balance & coordination
- draws a person w/at least 3 parts
- colors within lines
- uses scissors

Social/Emotional

- plays w/group of kids, (boys w/boys;girls w/girls)
- plays a role in pretend play
- follows simple game rules
- listens
- shares
- takes turns
- loves to whisper & have secrets

Language

- talks about experiences in detail
- tells meaning of familiar words
- follows series of 3 directions
- recognizes & names letters
- writes a few letters
- recognizes & reads some words in the environment

Cognitive

- counts 3+ objects by pointing
- counts to 30= by rote memory
- names & matches primary/secondary colors
- developing the sense of magnitude – heaviest to lightest, size & shape

5 Years

- gross motor skills well-developed
- can throw, kick, catch balls
- learning to understand rules & scoring in games
- ready to learn to ride small bike
- moves rhythmically to music
- handedness established
- uses writing materials successfully

- play is cooperative, particle, conforming
- learning concept of fair play
- likes group pretend play
- likes to make friends, impress friends

- attempts to write – uses invented & standard spelling
- recognized & identifies the sounds letters stand for
- enjoys writing & giving written messages to others
- enjoys reading favorite/simple books
- enjoys talking on the phone

- makes comparisons
- developing a sense of time
- knows full name, age, address, phone #, b-day
- prints own name
- spells familiar words
- matches numeral w/quantity
- developing an understanding of size, quantity, capacity
- sorts & matches by category
- vocational interest – “I want to be a …”

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Appendix 2: Costs for Typical Components

Item	Quantity	Cost	Comments
ABS	1 Kg	$1.50	General purpose paintable plastic
PPR	1 KG	$1.00	Non-paintable plastic- (not as stiff)
Small Screw	1000 pc.	$10	
AA Battery	1000 pc.	$80	For products that work on the shelf
4.5V DC motor	1000 pc.	$300	At max efficiency- 10,000 rpm, 13 g-cm
Mylar Speaker	1000 pc.	$100	Around 80 dB, 300- 10,000 Hz
64K IC	1000 pc.	$200	7.5 sec voice at 8 k/ sec., 8 I/0 ports
Super Brite LED	1000 pc.	$20	
Grain of wheat Bulb	1000 pc.	$40	a brighter, omni directional light
Button	1000 pc.	$50	
Microphone	1000 pc.	$130	

Appendix 3: Definitions

Children's Toy-	Toys developed for children over the age of 3 under the age of 10.
Pre-School Toy-	Toys developed for children under three years.
Passive Toy-	Toys without electronics or any other energy storage devise.
Smart Toy-	Toys that have an integrated circuit.
Kid Power-	The energy provided to the toy is input by the child.

References

http://www.cyberwalker.net/features/kids-tech-toys.shtml

http://www.powerpaper.com/5_news_pr/pr030212.htm