Design Alternatives for a
Cooling Teether for Babies

by

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ABSTRACT

Through a course offered by the Sloan School of Management, Design for Manufacturing, design consulting was performed for a local manufacturer and distributor of products for infants. The product in question is a water-filled, blue triangle teether. A soft blue vinyl triangle was filled with treated water allowing the teether to be cooled in the refrigerator. It also had an optional hard plastic white handle. Although an already successful product, the teether has not been reviewed in six years and needed an updated design.

New design ideas were analyzed from the company's perspective in terms of the design criterion of marketability, functionality, cost economy, and safety. Specific design issues of color, shape, size, texture and material were evaluated using the four design criterion. This was accomplished through the development a of specific methodology for each issue as it relates to each design goal. Lists of colors, shapes, sizes, and textures were originated and then evaluated with this methodology allowing each list to be ranked in terms of their ability to improve the design. Possible options for teether material were also investigated. Using the top ranking characteristics from the lists of colors, shapes, sizes, and textures, three new teether designs were recommended as well as specific redesign recommendations for the current teether design.

Red, blue, yellow, and pink are the top colors recommended for any teether. Bumps, line ridges, and raised lettering of the company logo are the three top textures recommended for a teether. Of the sizes analyzed, 2.5" x 2.5" x 0.5" is an optimal minimum volume size for containing a teether followed by 4.25" x 2.5" x 0.5" and 4.25" x 2.75" x 0.5". Of the list of shapes analyzed, sports logos, a turtle, and a panda where recommended for the teether redesign. Ethylene vinyl acetate, the current material used, proved to be the best material option. These specific results were combined to create three teether redesign options.

Thesis Supervisor: Dr. Steven D. Eppinger
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1.0 Introduction

This thesis is a result of part of a group effort which originated in the MIT course 15.785- Thesis Projects in Design for Manufacturing during the fall of 1989. In this course, three Mechanical Engineering seniors along with two Sloan School Master's students worked together to redesign a product for an industrial client.

The product examined (shown in Figure 1) is The First Years Cooling Teether manufactured by Kiddie Products, Inc. of Avon, Massachusetts. Kiddie Products, Inc produces products in the areas of feeding, bathing, play, toilet training and general child care. These items are marketed under "The First Years" brand name. The First Years line is sold nationwide to mass merchandisers, department stores, variety and drug chains, supermarkets and catalog showrooms. The company also distributes its products internationally.

The challenge of the Kiddie Products cooling teether project was to improve product safety and consumer appeal without adversely affecting product quality or performance. Emphasis was placed on marketing issues, product design and production methods. Kiddie Products, Inc., identified the following problems with the current teether: leakage at the seal, a sharp and rough cutoff, a sharp handle with crevices, and an outdated design. (Figure 1)

This thesis addresses teh creation of alternative design ideas. The design alternatives take into consideration the four design criterion of marketability, functionality, cost economy, and safety. Specific design issues of color, shape, size, texture and material were evaluated in terms of the four design criteria. This was accomplished through the development of a specific methodology for each issue as it relates to each design goal. Lists of colors, shapes, sizes, and textures were originated and then evaluated with this

methodology allowing each list to be ranked from best characteristic for the redesign to the worst. Possible options for teether material were also investigated. Using the top ranking characteristics from the lists of colors, shapes, sizes, and textures, three teether redesigns where recommended as well as specific redesign recommendations for the current teether design. This thesis provides a long term framework for product improvement. It develops a methodology for the complete redesign of the product. It also incorporates results of the other group member's efforts: consumer perception survey results, design analysis results, and handle redesign ideas.

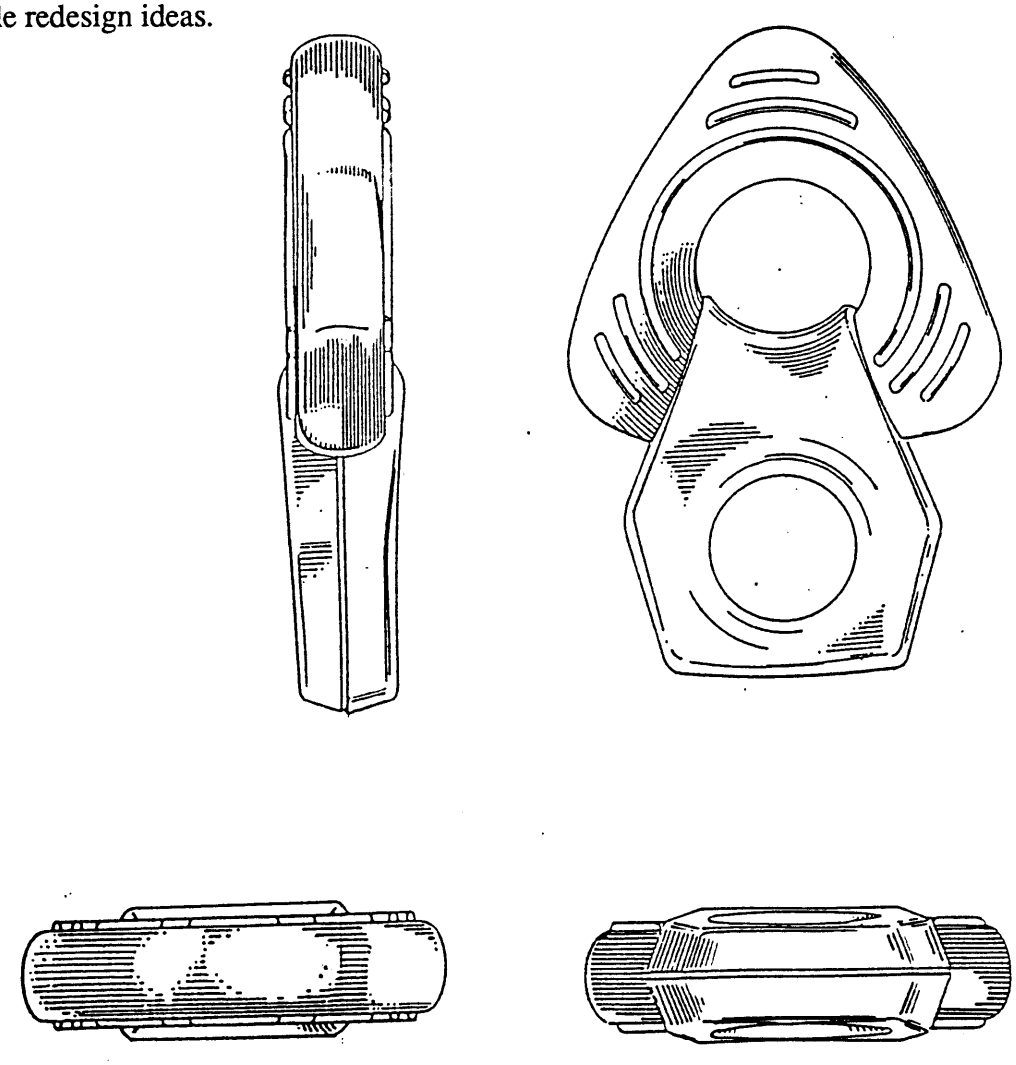

Figure 1: Current Cooling Teether Design

2.0 Evaluation of Current Design

The current design of the Cooling Teether is evaluated to determine its strengths and as well as its shortcomings. Categorizing the different attributes of the teether as either positive or negative will assist the redesign process.

2.1 STRENGTHS OF THE CURRENT DESIGN

The overwhelming popularity of the design as a therapuetic teether and its high sales rate, indicate that the design is a good one. Consumers perceived the Cooling Teether as safe, of high quality, strong, and of a material that is well suited for its application.[1] Also, production is quite inexpensive.

2.2 DESIGN SHORTCOMINGS

Kiddie Products Inc., has identified the following issues in redesigning the teether: leakage at the seal, a sharp and rough cutoff, a sharp handle with crevices, and an outdated design . The play value of the teether is virtually nil.[2] Market research shows that the Cooling Teether is not perceived at as a toy by consumers.[3] This greatly reduces the number of consumers that would buy the teether. Consumers desire play value in a teether so that it may interest and appeal to the child.[4] Consumers complain that the product is too big and thick for young babies. They also feel the design is boring (not colorful or

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[1] Theodore, Carolyn A., Marketing Analysis of a Childrens Product, S.M. Thesis, MIT Sloan School of Management, unpublished, 1990.
[2] Ibid.
[3] Ibid.
[4] Ibid.

interesting) and poorly shaped. It does not fit well into babies' mouths and does not reach the rear molars.[5] Any redesign should address these consumer complaints raised about the product. Many mothers suggested new ideas that may reflect this market demand. The new design should try to avoid incorporating these design shortcomings and should try to incorporate the strengths of the design to produce a design which embodies the desired characteristics of a cooling teether as best as possible.

3.0 Characteristics of a Cooling Teether

The characteristics of a cooling teether desired by the company and consumer alike include having a soothing and cooling effect on the child's gums and having appeal to both sight and feel.[6] This translates into a teether which is water-filled so that it can be cooled in the refrigerator. It also should have a handle to keep the cold from reaching the child's hands and a texture that sooths the gums of a teething child. Consumers feel strongly that a teether should be interesting to the child in the manner of a toy. It should also be easy for the child to hold.[7] To make a teether more appealing for children, bright and shiny colors which are attractive to a child should be used for the cooling teether. Other characteristics specifically desired by the consumer for the redesign of the present cooling teether is to make it thinner and smaller as well as to make it of a more interesting shape.[8] Design changes should incorporate these characteristics and at the same time be cost effective and safe.

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[5] Ibid.
[6] Ibid.
[7] Ibid.
[8] Ibid.

4.0 Definition of the Design Criterion

There are four basic criteria to consider when doing a product redesign. They are listed here in order of importance to the company along with a proposed weighting of importance for each: Marketability (40%), Cost Economy (30%), Safety (15%), and Functionality (15%).

Marketability was deemed most important because without a well defined market in which to sell, all other concerns are meaningless. Marketability includes the characteristics of the product which lead to sales. These characteristics are not necessarily related to the function or safety of the product. Marketability can be expressed as how well the product attracts and appeals to the consumer.

Cost Economy is directly related to profit. If the company can not make a profit, it does not matter how well the product functions or how safe it is because the company will stop selling it. A redesign should always consider its costs for new ideas. Sometimes more money spent on the production of a product is worth incorporating new design ideas, yet the options should be carefully evaluated to find the perfect balance between a good quality product and profit.

Safety is an important design concern because of government standards and the potential liability damage to a company from an unsafe product. There are over fifty types of tests that the Quality Assurance Department at Kiddie Products, Inc., uses to test their products. They are all related to regulations and standards set by the government. There is much concern on the part of Kiddie Products, Inc., about the safety of their products.

Functionality is important for the design because it determines the level of customer satisfaction after the purchase and is related to upholding the good name of the product line and company. Functionality is simply whether or not the product works.

The design criteria can also be ranked in order of importance to the consumer. This ranking is listed here along with the weighted of importance of each: Marketability (35%), Safety (30%), Functionality (25%), and Cost Economy (10%). The design criteria ranked in order of importance to the consumer are included because even though this thesis is being pursued with respect to a company's requirements, it may be instructive to evaluate the product with respect to a consumer's requirements and see if the results differ drastically from the corporate evaluation. If they do differ, a different means of developing products may suggest itself. This work is left for future exploration.

For the consumer, marketability is important because it is synonymous with being aesthetically pleasing. For example, interviewed consumers have expressed desired features which relate to the appearance of the teether including the size, shape, texture, and color. Marketability is more important than safety, because while safety is a major concern, most people know that the government regulates the safety of products of this nature and that if it were unsafe, the government would not allow the product on the market.[9] Also, interviewed consumers showed concern about desired features of the product than about the safety of the product. Nonetheless, safety is more important than functionability because of the inherent value of a baby to its parents. Cost is the least important because 'this is our baby' and because generally the price of teethers is generally less than three dollars.[10] Of the parents interviewed, none were dissatisfied with the cost of teethers. [11]

Each area of the design criteria was evaluated in terms of four elements. The elements addressed are shape, color, size, and texture of a teether. Materials were also briefly addressed. Marketability, for example, is defined as it pertains to the shape, color, size, and texture of a teether. Cost economy, safety, and functionality are also defined as

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[9] Ibid.
[10] Ibid.
[11] Ibid.

they relate to the shape, color, size, and texture of possible designs. The characteristics of shape, color, size and texture with respect to each design criterion are defined in subsequent sections.

Different shapes, colors, sizes, and textures have been evaluated separately according to the criterion for marketability, cost economy, safety and functionality. A score for each of the shapes, colors, sizes and textures is computed by taking a weighted product of the marketability, cost economy, safety and functionality as follows:

SCORE = (0.4*MANU)+(0.3*COST ECON)+(0.15*SAFETY)+(0.15*FUNC).

The score as a stand alone numerical value is meaningless. The higher a score the better that characterisic is compared to the others in the list. For example, if a shape 'A' scores higher than a shape 'B', the company should choose shape 'A' over shape 'B' for its teether. Once scores are computed for each of the shapes, colors, sizes and textures, these scores are compared and ranked relative to each other. The best shape, color, size, and texture according to this evaluation are combined to create the most favorable redesign for the teether. An iterative process is then utilized to form a final redesign from the top ranking components.

5.0 Design Issues

Different shapes, colors, sizes, and textures have been evaluated separately according to the criterion for marketability, cost economy, safety and functionality.

5.1 SHAPE ANALYSIS

Shape was evaluated in terms of its ability to satisfy the criterion of marketability, cost economy, safety, and functionality. Questions like, 'What shape appeals most to the consumer ?' and 'What shape does a teether have to be to be safe ?' were asked to assist in setting up the analysis for shape.

In the shape analysis, a detailed definition of the marketability of a shape is stated and a list of shapes is analyzed according to this criterion. The shapes are then ranked by giving the shape which satisfies the criteria the best the highest ranking number and so on. The same procedure is used to determine a ranking of the shapes for cost economy, safety, and functionality. A score for each shape was computed by taking a weighted average of the ranking numbers for the marketability, cost economy, safety and functionability of each shape. The final ranking of the shapes represents an ordering of scores from highest to lowest. This ranking determines the best shape for the redesigned teether.

After numerous brainstorming sessions which resulted in hundreds of ideas for the shape of a cooling teether, each idea was considered. First, the ideas which clearly were not acceptable were removed from the list. For example, the shape of a pen was removed because it is too long and would fail the impaction safety test. Thus, the rule that the shape must follow is the small parts criteria which is used to further the selection process. Once,

all the inefficacious ideas were removed from the list, eighteen shapes considered to be possible successful shapes were made into the list of shapes to be analyzed.

5.1.1 Shape Marketability Methodology

With respect to marketability, a good shape for a teether should catch the consumer's attention and appeal to him. A good way to determine successful shapes is to get a feel for what interests consumers have as well as what they are likely to buy for their children. For example, things found in a infants room are bought by parents for their children. These objects are likely to be shapes which appeal to parents and which are bought by the consumer for their children. Looking through advertisements in CHILD magazine, a list of objects placed in child's rooms in the advertisements was compiled and the number of times each object appears in the advertisements was recorded. (Appendix A.) To get a feel for the interests of parents, information was collected from articles found in CHILD magazine. From these articles, one can get a feel for the kinds of things parents are interested in and are likely to buy. Parents of the 1990s are interested in new technology that saves time, in all aspects of life including child rearing.[12] This information together with the list of objects found in a child's room is used for reference purposes while ranking the shapes in terms of marketability.

5.1.2 Shape Marketability Analysis

Referring to Figure 2, a relative ranking of all shapes with respect to marketability, the most appealing shape to the consumer would be the sports team logos. Parents would be very attracted to the sports teams logos as they would love to have their neighbors see

[12] "The Perfect Parent: 90s Style", CHILD Magazine, January/February 1990

little Johnny teething on a Bruins teether while everyone was over watching the game on TV. If the consumer had all these shapes in front of them as choices, then they would be least likely to chose the Gerber "eight" because its shape really does not have a purpose or secondary function. It would also be unpopular because geometric shapes was one of the least frequently spotted shapes in advertisements of infant's room. The range is set from the Gerber "eight" to the sports logos and the rest of the shapes are to be ranked relative to these bounds and each other. Ranked second are the college mascots for the same reason as the sports logos. MIT alumni that are parents, for example, would love to have their infant teething on a beaver mascot teether. The next important thing to parents after their child is their jobs.[13] Therefore, teethers handed out at the company picnic would go over as a hit with parents. Even if employees do not have a young infant, most usually they know someone who does. After their jobs, education of their children is important to parents. Thus, the letters and numbers are considered. Refering to the list of objects found in infants' rooms (Appendix A), parents are more likely to buy letter shaped object than number shaped objects.[14] So, letters and numbers are ranked respectively after the company logo. After all the above shapes, the next set of shapes most appealing to the consumer are the cute animals which they would tend to buy and put in their child's room. This is where the list of objects found in an infants' room as a indication of what a parent might buy for their baby is taken into consideration. They include bunnies, ducks, bears, dogs, elephants, frogs, dinosaurs. At the top of the "cute" list is the duck. A duck is a perfect match for a baby. When one thinks of symbols of Easter, they think bunnies, chicks and duckies. Also, ducks are the third most popular shape in an infant's room. Next comes the dinosaur because it was the only other creature shape which was part of the list of objects in an infant's room. After the dinosaur, the panda was ranked as the most marketable shape because even though it isn't on the list of objects in an infant's room, the

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[13] Ibid.
[14] Ibid.

panda shape is very cute and appealing. The turtle was ranked before the fish because a parent would reason the turtle to be more fun and useful for teething than the simple fish shape. Yet, the turtle is less appealing to a consumer than the panda shape and therefore is ranked under it. Of the remaining shapes to be ranked, the tooth provides appeal to the consumer because it promotes understanding of a tooth in your mouth. It is ironic that it is being used to sooth the pain caused by a tooth. The parent could also notice the root features which would satisfy the infant. The tooth was ranked after the fish because it is similar in functional shape but the fish is cuter for an infant to be playing with. The grape bunch was chosen because parents realize that child likes and is familiar with food. Of the remaining shapes to be ranked, the eighth note would be interesting for muscially inclined parents especially, but could attract the attention of any parent because everyone enjoys listening to some form of music. It is ranked after the grape shape because more consumers are familar with food than with music. Considering the shape of a mobius strip, a limited number of people would understand the phenomena behind the shape and get excited to purchase it, but this amount of consumers is even less than those familar with music. Therefore, rank the mobius strip after the eighth note. Similar reasoning holds true for the math symbol. Parents highly concerned with education would be attracted to a pie symbol, but this is also assuming that most parents are familiar with the pie symbol. Therefore, the consumer would buy the mobius strip or even the eighth note before the pie symbol. The remaining shapes to be ranked can be described as geometric shapes. Most parents would find the Gerber and Kiddie triangle teether a boring shape compared to most of the other shapes. Also, refering to the list of objects in the advertisements which have infant's room, geometric shapes ranked at the bottom of the list. Therefore, the Kiddie teether was ranked above the Gerber "eight" and the Gerber teether similar in design to the Kiddie one above it. Thus completes the ranking for shapes in terms of marketability.

5.1.3 Shape Cost Economy Methodology

The cost economy of a shape can be determined by the complexity of the shape. The more complex the shape, the more costly and less desirable the shape in terms of cost. Taking this criteria into consideration, the shapes are ranked with the most cost economic shape having the top ranking.

5.1.4 Shape Cost Economy Analysis

Using the criteria above, each shape was ranked relative to each other by looking at the picture of each shape (refer to Figure 2). Each shape was evaluated in terms of the smoothness or sharpness of its perimeter curves, the length of the seam, the number of holes the in the shape, and the number of apenditures in the shape. For every turn in the perimeter, hole, or apenditure a point was given to that shape. The shapes with the higher numbers were ranked lower than shapes with low numbers.

5.1.5 Shape Safety Methodology

The safety of a shape is related to the impaction test as well as to sharp seams and edges. If a shape is too narrow it will fail the impaction test, one of the regulations set by the government. To satisfy the impaction test, a shape must be a maximum of two inches long where it is one and a half inches wide and where it is one and a quarter inches thick. If all the shapes satisfy the impaction test and seams and edges are not sharp, then the shapes equally pass the shape safety criteria.

The safety of a shape can be determined by determining the aspect ratio of each shape. The aspect ratio is the ratio of the length to the width. For a given size, the smaller

the aspect ratio the better. In other words, the shape should be as round as possible for a given size to have little chance of being gagged on. The lower the value of the seam length of the teether (the part holding water) the better and less chance of breakage. Therefore, also for shape safety, minimize seam perimeter for a given size.

5.1.6 Shape Safety Analysis

To determine the safety of a shape, each shape must be tested with the impaction test as well as be inspected for sharp edges and seams. According to this criteria under which the shapes where designed, all the shapes pass the impaction test. As for the sharp edges and seams, it is assumed that any product can be made with no sharp edges or seams regardless of the shape. For example, the present design has no sharp edges or seams. Thus, all shapes in the list receive a top ranking value of eighteen. (Refer to Figure 2).

5.1.7 Shape Functionaility Methodology

The functionality of a shape can be determined by how well a shape gets and keeps an infants attention. Basically, it is the shape that works that satisfies the shape functionability criteria. According to information on teething found in a book titled, INFANTS AND MOTHERS: Differences in Development, by Dr. T. Berry Brazelton, teething occurs in babies starting around the age of four months with the lower front incisors and continues until around the age of one year when the molars come in.[15] Further detailed information on baby teething is included in Appendix B. In her book entitled PLAY, Catherine Garvey shows how child's play can have a systematic and rule-

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[15] Brazelton, Dr. T. Berry, Infants and Mothers, Differences in Development, (Belacorte Press, New York), 1969, p. 118,137,139,172.

governed nature.[16] One study states that when a variety of objects are placed near a nine month old baby, the infant is likely to grasp a nearer, brighter object and bring it to its mouth, or otherwise interact with it. In general the objects receive random treatment; no one shape is more appealing to a child than another. Even at twelve months, a child's actions are similar as he is likely to investigate each object first before doing anything else with it. Further information on play of a child is included in Appendix C. Considering this information, the functionability of a shape can be determined and ranked.

5.1.8 Shape Functionality Analysis

From the information used to define the shape functionality methodology, it can be concluded that teething babies are not attracted to any certain shapes. Therefore, all the shapes in the list are equally appealing to an infant and should receive the same ranking. Since there are eighteen shapes in the list, all shapes receive a top ranking of eighteen. (Refer to Figure 2). Another point to consider is whether the shape can reach the back teeth of the teething child. This is aspect of the analysis is dealt with in the size analysis.

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[16] Garvey, Catherine, Play, (Harvard University Press, Cambridge), 1977, p41-55.

	RANK	MARKETABILITY	COST ECONOMY	SAFETY	FUNCTIONABILITY	SCORE
SHAPES (18)						
Dinosaurs	**9**	12	7	18	18	12.3
Grapes	**6**	7	15	18	18	12.7
Turtles	**3**	10	16	18	18	14.2
Fish	**9**	9	17	18	18	12.3
Panda	**3**	11	11	18	18	13.1
Sports Logos	**1**	18	10	18	18	15.6
Company Logos	**3**	16	8	18	18	14.2
College Mascots	**2**	17	7	18	18	14.3
Letters	**10**	15	1	18	18	11.7
Numbers	**11**	14	2	18	18	11.6
Math Symbols	**18**	4	4	18	18	8.2
Mobius Shape	**7**	5	18	18	18	12.8
1/8th note	**15**	6	5	18	18	10.5
tooth	**13**	8	9	18	18	11.3
Gerber-small 8	**17**	1	14	18	18	10
Gerber - copy	**15**	3	13	18	18	10.5
German - Duck	**12**	13	3	18	18	11.5
Kiddie Triangle	**16**	2	13	18	18	10.1

Figure 2 : Shape Analysis

5.2 COLOR ANALYSIS

Color was evaluated in terms of its ability to satisfy the criterion of marketability, cost economy, safety, and functionality. Questions like, 'What colors do parents find most appealing ?' and 'How much does it cost to color a teether red ?' were asked to assist in setting up the analysis for color.

In the color analysis, a detailed definition of the marketability of a color is stated and a list of colors is analyzed according to this criteria. The colors are then ranked by giving the color which satisfies the criteria the best the highest ranking number and so on. The same procedure is used to determine a ranking of the colors for cost economy, safety, and functionality. A score for each color was computed by taking a weighted average of the ranking numbers for the marketability, cost economy, safety and functionality of each color. The final ranking of the colors represents an ordering of scores from highest to lowest. This ranking determines the best color for the redesigned teether.

The top thirteen most frequently used colors for toys for children around a year old found at FAO Schwartz toy store in Boston, Massachusetts, were analyzed with respect to manufacturability, cost economy, safety and functionality in accordance with the color design methodology.

5.2.1 Color Marketability Methodology

With respect to marketability, a good color for a teether catches the consumer's attention. Many interviewed mothers feel the current blue was too bland. Many suggest the use of brighter colors and pastels.[17] To determine the best colors for a teether, a survey was made of the colors of the top selling toys for children of the teething age at

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[17] Theodore

FAO Schwartz toy store in Boston, Massachusetts. If a toy is a successful seller and the toy has a color, then that color is part of the reason for the success of that toy. If the toy was not a successful seller, then the toy company would take the product off the shelf. This is not a definitive means of determining an optimal color because it takes only a small sampling of colors on the market, but if it was done on a large scale it might provide accurate information. The purpose here is to demonstrate a possible method for future analysis. Also, their are certain colors which are good for a child's toy, but not acceptable for an infant's teether. For example, a mother would not encourage her child to put a black or grey teether into his mouth.[18]

5.2.2 Color Marketability Analysis

To determine the marketability of a color, the color schemes of successful toys for teething aged kids sold at FAO Schwartz toy store was investigated. (Appendix D.) The logic was that if the toys are on the shelf, then they must be successful sellers and their colors are related to that success. The number of times a color appeared on a toy was recorded. About 35 toys were sampled. The colors were then scored highest for the most popular to lowest for the least popular. This methodology assumes that the store never runs out of stock nor does it have an over stock of toys.

Discussion with a colorant supplier who deals frequently with products for infants, made it clear that blues and pinks are especially popular colors and primary colors along with combinations thereof are also frequently used in children's products. It was also made clear that teethers of colors such as black and grey would never be given to a baby by a mother; therefore these colors were given the score of zero. This ranking is indicative of

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[18] Bruce Williams, Approved Color Co., Greenville, NH

marketability because it has to do with appeal to the consumer. A good color should catch the attention of the consumers and appeal to them. (Refer to Figure 3).

5.2.3 Color Cost Economy Methodology

The cost economy of a color is directly related to the cost of colorant. The cost for the color pigments used as colorant needed to be determined. Cost information for different colors was obtained. (Appendix E.) Since the cost of a colorant varies depending on the form, the quantity of colorant ordered, the brightness of the color desired, the transparency of the color, and whether or not a FDA approved color is necessary, an exact price per pound can not be determined. An estimate was made.

Colorants come in three different forms: powder, liquid, and resin pellets. The form presently used is the resin pellets. The material used to make the product is combined with a color pigment to create a concentrate of the color. The color concentrated material is extruded and cut into pellets. The cost of the resin pellets depends directly on the cost of the base material. It is also dependent on how concentrated the color is in the pellet. The brighter or darker a color is desired, the higher concentration necessary, and therefore the higher the cost. The shininess of a color is created by a smooth surface of the mold and therefore is not a function of the colorant.

A hypothetical case which fits the characteristics of the present teether was used to determine average prices per pound for each color. It was assumed that an order of 200 lbs is placed for a colorant in the form of ethylene vinyl acetate resin pellets to determine prices for each color.

5.2.4 Color Cost Economy Analysis

The cost economy of a color is directly related to the cost of colorant. The relative ranking of colors in terms of cost economy reflect the prices obtained. The colors were ranked according to their cost, with the most expensive having the lowest score. (Refer to Figure 3).

5.2.5 Color Safety Methodology

The safety of a color is dependent on whether or not the colorant is toxic or dangerous to a child in any way. If a color is FDA approved, then it is guaranteed that the colorant is safe. If all the colors are safe, then they all receive the same top ranking value. If a colorant is unsafe, then it should receive a value of negative infinity so that it can not be considered as an optional color.

5.2.6 Color Safety Analysis

All colors were given the top score of thirteen (there are thirteen colors being evaluated) for safety because all the colors are available for children's products and are safety approved as regulated by the FDA. (Refer to Figure 3).

5.2.7 Color Functionality Methodology

The functionality of a color is directly related to how the color attracts the attention of teething children. The more attractive the color to the child, the more functional.

5.2.8 Color Functionality Analysis

Infants and children around the teething age are not attracted to specific colors, but to bright shiny colors in general. So, the functionality of the colors listed is the same for each color because all colors attract the attention of a child.[19] Each color on the list is given a top ranking value of thirteen. (Refer to Figure 3).

	RANK	MARKETABILITY	COST ECONOMY	SAFETY	FUNCTIONABILITY	SCORE
COLORS (13)						
Yellow	3	13	4	13	13	10.3
Powder Blue	9	6	8	13	13	8.7
Blue	2	10	9	13	13	10.6
Navy Blue	6	6	10	13	13	9.3
Red	1	11	12	13	13	11.9
Lime Green	11	6	6	13	13	8.1
Green	5	9	7	13	13	9.6
Purple	8	3	13	13	13	9
Pink	4	7	11	13	13	10
Gray	12	0	3	13	13	4.8
Black	13	0	1	13	13	4.2
White	6	12	2	13	13	9.3
Orange	10	8	5	13	13	8.6

Figure 3 : Color Analysis

[19] Garvey

5.3 SIZE ANALYSIS

Size was evaluated in terms of its ability to satisfy the criterion of marketability, cost economy, safety, and functionality. Questions like, 'What size teether fits best in an infant's hand and mouth ?' and 'What size does a teether have to be to be safe ?' were asked to assist in setting up the analysis for size.

In the size analysis, a detailed definition of the marketability of a size is stated and a list of sizes is analyzed according to this criteria. The sizes are then ranked by giving the size which satisfies the criteria the best the highest ranking number and so on. The same procedure is used to determine a ranking of the sizes for cost economy, safety, and functionality. A score for each size was computed by taking a weighted average of the ranking numbers for the marketability, cost economy, safety and functionability of each size. The final ranking of the sizes represents an ordering of scores from highest to lowest. This ranking determines the best size for the redesigned teether.

The list of fourteen sizes being evaluated originated from sizes of teethers already produced. This teether sampling includes teethers from Kiddie Products, Inc., as well as from other companies.

5.3.1 Size Marketability Methodology

Marketability is the ability of the product to appeal to the consumer. With respect to marketability, a good size for a teether is one which fits easily in a child's hand and mouth. The size should meet the above criteria for a wide range of ages. Some mothers complained that the current model was geared to children over three months old to

exclusion of younger infants.[20] Safety requires that the teether be at most 2 inches long where it is at most 1.5 inches wide and for a height of at most 1.25 inches.[21] To be safe, a teether can not have any narrow ends. Since the design took the impact test into consideration when the designs were being created, this criteria was satisfied. The best manufacturing sizes are determined according to how far off the size is from an ideal size. Evaluation of size is done by taking the absolute value of the ideal length minus the length of the dimension being examined and similarly for the width and thickness. The difference is summed giving a total value which the size dimensions are off from the ideal dimensions:

$$\text{Distance of error} = |\, lo - l \,| + |\, wo - w \,| + |\, to - t \,| \qquad (1)$$

where "l" is the length, "w" is the width, and "t" is the thickness. The size for a teether has the smallest 'distance of error' value and is therefore ranked highest in the overall relative ranking of the sizes.

5.3.2 Size Marketability Analysis

The ideal size for a baby teether was determined. First, a teether should reach the back teeth of a teething child. If a teether was two inches thick, it would never fit in an infant's mouth to reach the back teeth. For perspective, the average size of a babies spoon (the part put in the babies mouth) is one inch by one-half inch. The current teether uses a thickness of 3/4 inch which many consumers have stated in the interviews is too thick.[22] Taking the consumer's opinion into consideration and the thickness of the current teether, the thickness of 1/2 inch was proposed to be an optimal value. The ideal length and width of a teether is determined by the average size of a teething child's hand. The average length

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[20] Theodore

[21] Standard Consumer Safety Specifications on Toy Safety, "American Society for Testing and Materials Designation #963-86", Phildelphia, 1986, p. 16.

[22] Theodore

of a teething child's hand is 4.25 inches.[23] (Appendix F.) 44% of the length of a child's hand is the length of its fingers.[24] A child uses primarily its fingers to pick up an object. A good estimate for the width of a teether, is the length of a child's fingers or about two inches. Even though holes aid the child in picking up teethers, they are not necessary for teethers with the optimal width of two inches. The ideal length of a teether is related to the child's hand size. Too long and the child may have difficulty picking it up or may hurt himself. A good estimate for the length of a teether, is double the hand breadth of a child's hand or about 3.5 inches.[25] (Appendix G.) Thus, the optimal size for a teether is 3.5" x 2" x 0.5". Having set the optimal dimensions, each of the size options (length, width, and thickness) was scored according to how far off the size is from the ideal size. This was done by using equation (1). The sizes were then ranked, with the best score being given to the size dimension closest to the ideal dimension. (Refer to Figure 4).

5.3.3 Size Cost Economy Methodology

The cost economy of a design is related to the size such that the bigger the design, the more it will cost in terms of both plastic material and difficulty to manufacture. Using the dimensions of the sizes in the list, the smallest volume which would contain the shape is computed. Then the sizes are ranked with the top ranking for the smallest volume, and lowest ranking for the largest volume.

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[23] Anthropometry of Infants, Children and Youths to Age 18 for Product Safety Design, Snyder, Richard G., et. al., (US Department of Commerce for CPSC, Bethesda), 1977, p565-568.

[24] Ibid.

[25] Ibid.

5.3.4 Size Cost Economy Analysis

The length, width, and thickness of various teethers were recorded to develop the list of fourteen dimensions. These dimensions create the smallest rectanglar volume which fits around the object. After calculating this volume and recognizing that the bigger the teether is the more it will cost in terms of both material and manufacturing, the sizes were ranked with respect to the volume with the smallest value receiving the highest score. (Refer to Figure 4).

5.3.5 Size Safety Methodology

The criteria for size in terms of safety is simply whether or not the size passes the impaction test. This is the threshold about which a size is safe. In general, this means smaller teethers are less safe. The designed size should not be too small. If the size passes the impaction test, then it receives a top ranking value, meaning a ranking of eighteen because there are eighteen colors. If the size does not pass the impaction test, then it recieves a bottom ranking value of negative infinite because if a design is unsafe and it must not be a component of a final design.

5.3.6 Size Safety Analysis

Checking all the size dimensions against the restricting requirements of the impact test, all the sizes were safe and received a top ranking value of eighteen. (Refer to Figure 4). This safety requirement will be more completely satisfied under safety in the shape analysis.

5.3.7 Size Functionality Methodology

The criteria for size in terms of functionality is the same as the criteria for size in terms of marketability. A good size should easily fit into a child's hand or mouth and should be long enough to reach the back teeth of an infant which is about 1.5 inches deep into the mouth.

5.3.8 Size Functionability Analysis

First, by checking all the size's lengths, it was determined that they are all at least 1.5 inches long and able to reach back into an infant's mouth. Then, with the ideal size for a teether set at 3.5" x 2" x 0.5" in the size marketability analysis, the sizes were ranked according to how far off they were from the ideal size, thus determining the more functional sizes. (Refer to Figure 4).

	RANK	MARKETABILITY	COST ECONOMY	SAFETY	FUNCTIONABILITY	SCORE	Volume
SIZES (14) (lxwxt)							
4.25" x 2.75" x .75"	9	8	6	18	8	8.9	3.77
2.50" x 2.75" x 5/8"	7	7	10	18	7	9.55	4.3
2" x 2" x .5"	2	12	14	18	12	13.5	2
4" x 2" x .5"	1	14	11	18	14	13.7	4
4.5" x 2.5" x .5"	5	12	9	18	12	12	5.63
3.75" x 3" x .75"	6	12	7	18	12	11.4	8.44
4" x 2.5" x .75"	4	13	8	18	13	12.25	7.97
2.5" x 2.5" x .5"	3	12	13	18	12	13.2	3.13
4" x 1.5" x 2"	10	6	5	18	6	7.5	12
2" x 1.25" x 1.25"	8	6	12	18	6	9.6	3.91
4" x 2.5" x 2"	11	6	1	18	6	6.3	20
3" x 3" x 2"	13	3	2	18	3	4.95	18
2" x 2" x 3"	14	1	5	18	1	4.75	12
4" x 4" x 1"	12	3	3	18	3	5.25	16

Figure 4 : Size Analysis

5.4 TEXTURE ANALYSIS

Texture was evaluated in terms of its ability to satisfy the criterion of marketability, cost economy, safety, and functionality. Questions like, 'What textures do parents find most appealing ?' and 'How much does the cost of production change for different textures ?' were asked to assist in setting up the analysis for texture.

In the texture analysis, a detailed definition of the marketability of a texture is stated and a list of textures is analyzed according to this criteria. The textures are then ranked by giving the texture which satisfies the criteria the best the highest ranking number and so on. The same procedure is used to determine a ranking of the textures for cost economy, safety, and functionality. A score for each texture was computed by taking a weighted average of the ranking numbers for the marketability, cost economy, safety and functionality of each texture. The final ranking of the textures represents an ordering of scores from highest to lowest. This ranking determines the best texture for the redesigned teether.

The list of texture originated from a brainstorming session and further selection analysis like the one used to determine the list of shapes that were analyzed.

5.4.1 Texture Marketability Methodology

The marketability of a texture is a measure of whether or not the product looks soothing. Feel is not important for marketability because when a consumer buys a teether, they can see the texture but can not feel it. Ridges, bumps and some non-uniformity of surface define a good texture for this. A good texture should also look pliable (rubber as opposed to glass).

5.4.2 Texture Marketability Analysis

Each texture was viewed in order to determine whether it was "soothing". Ridges and bumps were considered the best textures because rubbing against bumps and not against a smooth surface provides simulation to the nerve endings. The bubble ridges looked the most soothing of all the textures listed because of the regularity of the texture pattern. The line ridges and logo ridges (which are the company's logo raised on the plastic) follow close behind in appearing soothing. The items that were not uniform in texture were considered the next group of most soothing textures such as the grass, wool, and pine needles. The smooth textures like glass and shiny metal followed the non-uniform textures even though they have no ridges or unevenness to rub against the gums, the texture still is not abrasive in appearance. The gravel, sandpaper, grass and dirt are considered rough textures which do not look very soothing. The sandpaper looked the most abrasive. These items were ranked lowest among textures. (Refer to Figure 5).

5.4.3 Texture Cost Economy Methodology

The cost economy of a texture is directly related to the irregularity of the surface. The more irregular the texture, the more it will cost to make the molds. A pattern with many different sub-patterns is expensive. For example, it would cost more money to tile a floor with white tile that had specs of black tile to break up the white than it would cost to just tile the floor all white. This includes whether the texture varies over part of the surface or if it is a complex curve, etc. Also, if the texture is more complex, the material costs are likely to be increased. In more quantitative terms this can be looked by having the cost be determined by the number of different textural features seen per square inch.

5.4.4 Texture Cost Economy Analysis

Each texture was examined for irregularity as well as for variation of texture over the part. The more complex textures like the gravel, pine needles, fur, felt and wool were ranked low. While simple textures like glass, wax and shiny metal were ranked at the top of the list. (Refer to Figure 5).

5.4.5 Texture Safety Methodology

Textures were determined to be safe if they could be considered as not harmful to a child who would be rubbing it in his mouth. A texture is either safe or unsafe. The first step in determining this was by selecting the smoothest and the most abrasive of the textures. Then the rest of the textures were listed relative to each other to complete the ranking. There exists a safety threshold for which all the textures smoother than the threshold texture are safe. Those textures at and above the safety threshold all received a top score because they are equally safe.

5.4.6 Texture Safety Analysis

Each texture was examined for smoothness and abrasiveness and the question 'Is the texture safe ?' was asked of each texture. All the safe textures were given the top ranking value of twenty. Since the rest of the textures were unsafe, they were given a value of negative infinity because the unsafe textures must not be considered as possible textures for the teether redesign. (Refer to Figure 5).

5.4.7 Texture Functionality Methodology

The functionability of a texture is related to how the texture feels. Functionality of texture is how it feels while the marketability of texture is how it looks because your can only see the texture in the packaging. Ridges, bumps and some non-uniformity of surface define a good texture in this area because they feel soothing as they are rubbed against one's skin. A good texture should also be pliant (rubber as opposed to glass). A smooth texture like glass does not stimulate the senses. An unsatisfactory texture would not sooth an infant's gums if rubbed against them. A texture that is abrasive is not functional at all because it may bring harm to the child.

5.4.8 Texture Functionality Analysis

Each texture was touched in order to determine functionality. If the texture felt abrasive, it was given a ranking value of zero because it is not functional. The textures that were smooth were given the lowest values and the rankings improve as the feel of the textures increased with respect to non-uniformity. The bubble and line ridges were ranking highest because they felt most soothing. (Refer to Figure 5).

	RANK	MARKETABILITY	COST ECONOMY	SAFETY	FUNCTIONABILITY	SCORE
TEXTURES(20)						
Shiny Metal	11	4	20	20	5	11.35
Hair	13	8	12	20	9	11.15
Skin	15	7	11	20	8	10.3
Pants	6	11	10	20	11	12.05
Shirt	12	10	9	20	10	11.2
Line Ridges	2	19	18	20	19	18.85
Bubble Ridges	1	20	18	20	20	19.4
Glass	9	5	19	20	6	11.6
Dirt	0	13	4	-200	0	-23.6
Grass	4	17	5	20	17	13.85
Wax	14	6	15	20	7	10.95
Kleenex	10	9	8	20	16	11.4
Pine Needles	0	3	3	-200	0	-27.9
Fur	8	15	2	20	14	11.7
Wool	7	16	1	20	15	11.95
Felt	16	14	6	20	13	5.6
Gravel	0	2	7	-200	0	-27.1
Jeans	5	12	13	20	12	13.5
Logo Ridges	3	18	18	20	18	18.3
Sand Paper	0	1	14	-200	0	-25.4

Figure 5 : Texture Analysis

5.5 MATERIAL ANALYSIS

What do we desire in a material for the Cooling Teether? It is necessary that the material remain flexible (elastic) at lower temperatures so that no cold crack failures occur when the teether is cooled in the refrigerator. A lower water vapor transmission rate than that of ethylene vinyl acetate is desired so as to reduce the shelf life of the teether. The material should also be less sticky than the vinyl so that it is easier to fill. It should be soft and clear as well as cheap. The material should be able to undergo blow molding and ultrasonic welding processes. It should also be available in the form of resin pellets and be conducive to colorants. The resulting material best suited for these needs is the currently used material, ethylene vinyl acetate.

The present material used for the cooling teether is low density ethylene vinyl acetate, or EVA. The acetate component gives the material a bubble gum like characteristic and makes the material clearer. The ethylene component makes the material less like vinyl and more like a milky material similar to the material used in many watchbands. It also makes the material opaque.

EVA is compatible with the blow molding process and the water-filling process used to manufacture the current design. It is flexible and transparent (low density). The low density property can be expressed in terms of the number of parts that can be made from a pound of material. Forty-five teethers can be manufactured from one pound of material, unlike a higher density material like a urethane which would only produce about a dozen parts per pound of material. A flaming process would remove the rough edges of the teether which concern the consumer and company alike, but EVA can not be flamed because it has a low melting point and gets soft at around 150 degrees Farenheit. Another problem with EVA is that it has a water vapor transmission rate which gives a shelf life to

the teether. Because the shelf life of a teether is longer than the period of time a baby usually spend teething, it has little detriment to the success of the teether.

Other materials were considered, but none came close to being able to replace EVA. Urethanes (polyether and polyester), for example, are stronger and more puncture resistant than calendared vinyl and EVA, and maintain thier elastic qualities at low temperatures. But, they have higher water vapor transmission rates than EVA which would make the shelf life more of an issue. Also, urethanes are expensive compared to the cost of EVA. Due to its higher density, urethane material would produce fewer teethers per pound of material.

The properties of ethylene vinyl acetate are satisfactory for the material needs of the Cooling Teether.

6.0 Results from the Design Issues Analyses

The top ranking element from the list of shapes is the sports logo. A Celtics Shamrock was used as the example for a sports logo, even though any logo can be used. The primary goal of such a shape is to capitalize on the enormous interest Americans and foreigners have for U. S. sports teams. Many people purchase insignia clothes. Drawbacks about this shape idea include whether the manufacturing process is flexible enough to produce different kinds of sports logos, the need to acquire licensing for the design, and the distribution requirements. One would not want a Celtics Shamrock teether to be sent to Chicago.

The shape of a college mascot was ranked second. The idea is related to the sports logos by targeting a specific interest with a huge captive audience. Especially for young adults just out of college who want to continue to support their school, they would enjoy doing so by buying a teether in the form of their school's mascot. The third shape on the list is the form of a company logo. This is the idea of having teethers handed out to employees to promote the company image. This strategy would work well at company picnics and other company activities. Yet, again the market could be viewed as too limited to be effective and the other issues of the flexibility of the manufacturing process and the distribution requirements exist in this case also. The next highest ranking shape is that of a turtle, a very good, widely accepted shape. This is followed by the shape of a panda. The sports logo, the turtle and the panda are the three shapes that will be expanded on in Section 7.0.

The top four colors for a cooling teether design are red, blue, yellow and pink. All four of these color will be utilized in developing three new design concepts in the next section.

The optimal sizes for a cooling teether are expressed by the dimensions which just enclose the shape of the teether (ie the minimum volume). The top dimensions are as follows:

2.5" x 2.5" x 0.5"

4.25" x 2.5" x 0.5"

4.25" x 2.75" x 0.5"

These sizes will also be used to created the new design concepts.

The best textures from the list of twenty examined are the bubble textures like those found on Gerber teethers, line ridges like those currently found on the present design, and logo ridges. Logo ridges are simply the company's logo raised in the material. These top three textures are incorporated into new design concepts in the following section.

A summary of the results are in Table 1.

TABLE 1: TOP RANKING RESULTS FOR THE DIFFERENT DESIGN ISSUES

Top Shapes	Top Colors	Top Sizes	Top Textures
1. sports logo	1. red	1. 2.5" x 2.5" x .5"	1. bubble ridges
2. college mascot	2. blue	2. 4.25" x 2.5" x .5"	2. line ridges
3. company logo	3. yellow	3. 4.25" x 2.75" x .5"	3. logo ridges
4. turtle	4. pink		
5. panda			

7.0 Three New Design Concepts

From the results of the design issues analyses, top ranking shapes, colors, sizes, and textures were determined. These elements were combined to create three new design concepts.

The first new design concept is a combination of the turtle shape, the color yellow, the dimensions of 2.5" x 2.5" x 0.5" and the bumps texture. This is a very practical design, yet sensitive to the desire of being more toy-like. It is called "Teething Turtle" and is shown in Figure 6.

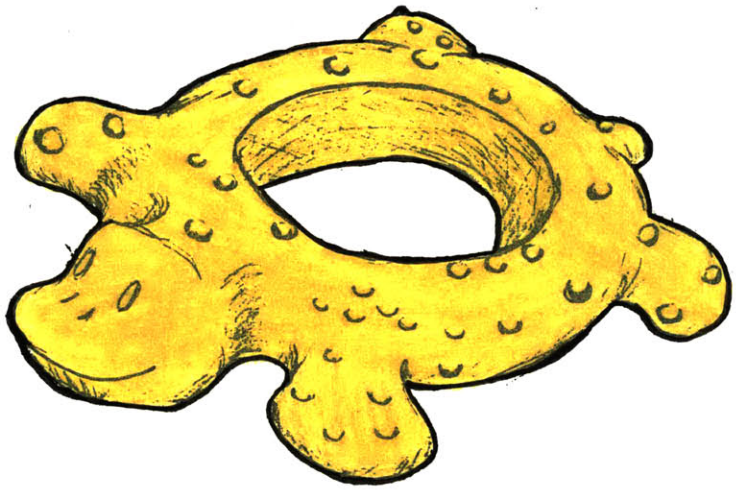

Figure 6: "Teething Turtle"

The second new design concept is a combination of the sports logo shape (a Celtics Shamrock), the color green, the dimensions 4.25" x 2.75" x 0.75", and the line ridges for the texture. It is called "Sports Teether" and is shown in Figure 7. Note, that the design incorporates a new snap on handle design as suggested by Mark Lester.[26]

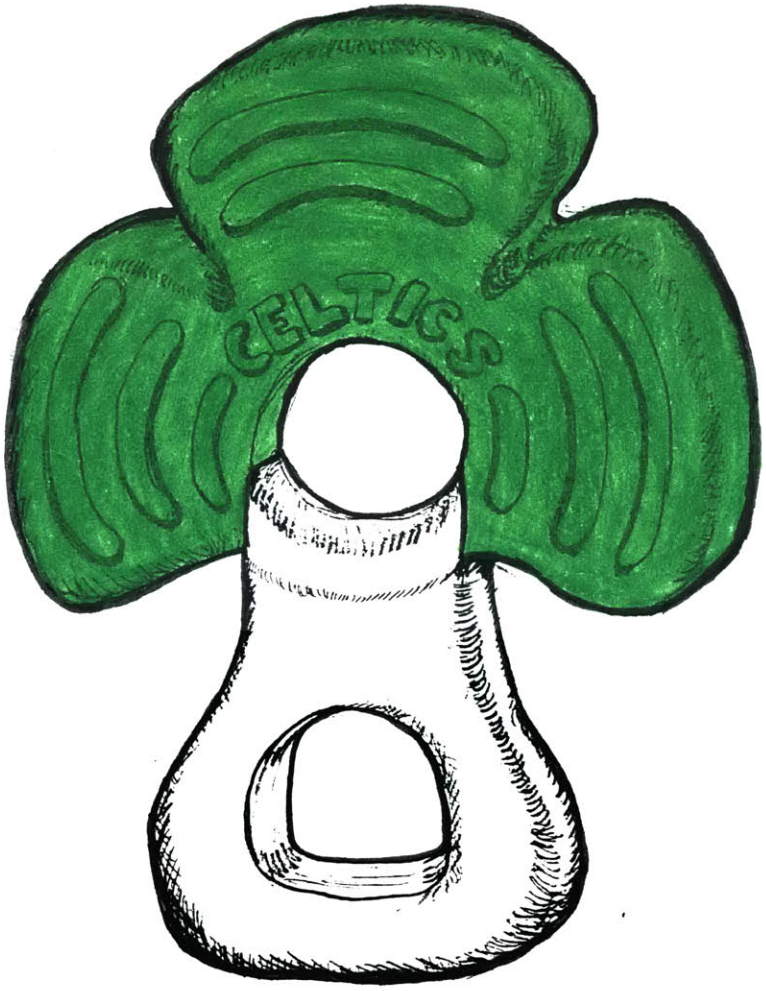

Figure 7: "Sports Teether"

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26 Lester, Mark, Design Alternatives to Improve Consumer Appeal and Manufacturability of a Water-Filled Teether for Babies, S. M. Thesis, MIT Sloan School of Management, unpublished, 1990.

The third and final new design concept, "Teething for Fun", is a combination of the panda shape, the colors both pink and blue (this design would be produced in both colors for boys and girls), the dimensions of 4.25" x 2.5" x 0.5" and the logo texture. It is shown in Figure 8.

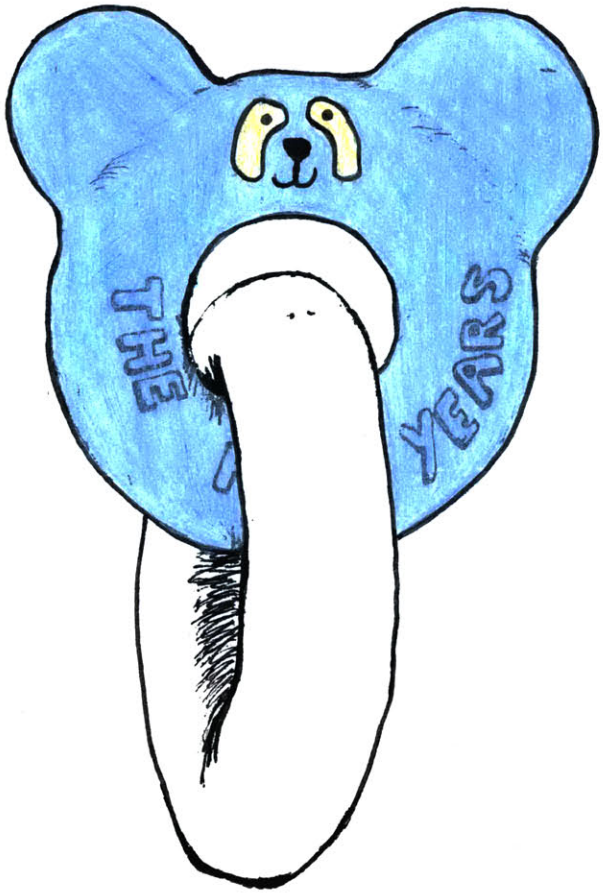


Figure 8: "Teething for Fun"

These different top ranking shapes, colors, sizes, and textures can be arranged by taking the best element from each category and combining them. All redesigns of the cooling teether should incorporate the same material currently used (EVA). Also, all the new designs are capable of being manufactured using the blow molding process which the current design uses.

8.0 Recommendations and Conclusions

Design consulting was performed for a local manufacturer and distributor of products for infants. A water-filled, blue triangle cooling teether was reviewed. Although an already successful product, the teether needed an updated style. Four design goals of marketability, functionality, cost economy, and safety were applied to new design ideas and analyzed from the company's perspective. Specific design issues of color, shape, size, texture and material were evaluated using the four design goals. This was accomplished through the development of specific methodology for each issue as it relates to each design goal. Lists of colors, shapes, sizes, and textures were originated and then evaluated with this methodology allowing each list to be ranked from best characteristic for the redesign to the worst. Possible options for teether material were also investigated. Using the top ranking characteristics from the lists of colors, shapes, sizes, and textures, three teether redesigns where recommended as well as specific redesign recommendations for the current teether design.

The following are specific recommendations for Kiddie Products, Inc.:

- Adopt a redesign of the Cooling Teether utilizing one of each of the top ranking shapes, colors, sizes and textures. Already developed new design concepts suggested are the "Teething Turtle" and "Teething for Fun", the panda design.
- Continue using the ethylene vinyl acetate material for the teether.

The following items are for further investigation:

- Analyze the design issues according to the consumer's needs and compare them to the results of the analysis for the company.
- Create more expansive lists of shapes, colors, sizes, and textures and redo the analysis.
- Consider manufacturing flexibility (cost of molds, etc.) to produce lower volumes of more shapes when choosing new designs.

Appendix A : Shapes in CHILD Magazine

Looking through advertisements in CHILD magazine from January through April 1990, a list of objects placed in child's rooms in the advertisements was compiled and the number of times each object appears in the advertisements was recorded. The list is as follows:

Object	# of times the object was spotted in ads.
Bunny Rabbitt	7
Piggy	1
Bear	16
Duck	6
Sheep	1
Frog	3
Mouse	1
Dog	5
Elephant	3
Numbers	3
Letters	6
Dinosaur	4
Geometric Shapes	1
Horse	5

Top Four Objects Most Frequently Occuring in Advertisements:

1. Bear
2. Bunny Rabbitt
3. Letters
4. Duck

Appendix B : Information on Baby Teething

The following information is from INFANTS AND MOTHERS, Differences in Development, by Dr. T. Berry Brazelton. Excerpts about the actions of a child during the teething period are explained by Dr. Brazelton as normal teething behavior.

The mother of an average four month old baby describes her sons actions. "Drooling was accompanied by a lot of finger-sucking and of exploring in his mouth with his hands. He seemed to have his hands in his mouth a large part of each day." A study of extra-nutritional sucking with charts by mother observers shows that as much as four hours a day is often spent at this activity. Is this combination of salivation, finger sucking, and shortening interest in the breast an indication of early teething ?

A explanatory reply from Dr. Brazelton describes teething in association with the actions of the four month old baby. "This may be a teething syndrome, but these activities occur in the fourth month anyway. The more agile use of his hands and widening interest in things around him contribute to all of this exploration, which also shortens feedings."

The lower front incisors come in first. A tooth, as it comes, acts like a foreign body (e.g., a splinter) and causes swelling and irritation of the gums around itself. By rubbing this swelling with a clean finger or ice in a handkerchief, one rubs out the swelling and relieves the aching for a time. When the baby sucks, blood rushes into his gums. This extra blood adds engorgement to the swelling that is already present. Sucking then hurts an already swollen gum. A baby rubs at his own gums as if to reduce the pain. As he finds chewing and rubbing on his own gums reduces pain, he begins to rub around them and on his face. The same nerves to the teeth branch out to the face, cheek, and outer ear. He finds it helps pain to rub his jaw and pull on his ear as if he has an earache. It thus may

be difficult for a mother to differentiate an earache from a toothache. Obviously, she can rub the baby's gums and find out whether it is sore. When one starts rubbing on a teething gum, the infant lets out a yowl which will be the tipoff that it is the source of discomfort. Continue the rubbing, and he will settle down. Using a temporary painfiller such as aspirin by mouth, or paregoric on the gums, may help also.

The mother of a quiet, five month old baby describes her daughters actions. "Buildup in activity...She handled her developing awareness in an entirely different way. Her sucking on fingers and toys was increasing in intensity, as she lay looking around with wide, knowing eyes. She had learned to bring her feet to her mouth and even sucked on her toes. She also chewed now as she sucked on her thumb. With a toy, she mouthes and chewed on every available edge. As she did, she seemed to savor each separate facet of it. No longer was the soft, red ball her favorite toy. She liked harder objects with corners which were cool to her gums."

Dr. Brazelton explains this activity by the young, quiet infant. "Investigation is spurred by application of these objects to swollen gums. Chewing on a cold object has the effect of reducing swelling, as does rubbing the gums. The relief afforded in chewing activity heightens the value of mouthing."

Another mother describes the actions of her daughter. "Laura smacked her lips, clicked her tongue and learned to cough over and over. She even learned that with a series of coughs one of her parents would rush to her bedside."

According to Dr. Brazelton, "The coughing may first be triggered by th increased salivation that goes with teething. An infant masters the cough, and he repeats it over and over. The cough is a dry hack that sounds like a smoker's cough. It can be told from a significant cough by the way it can be produced at will."

The mother of a quiet, seven month old baby describes her daughters actions. "Laura spent a lot of time chewing on her fingers, and sucking her thumb. She rolled her

head in bed, rocking it back and forth. This rolling activity stirred up Mrs. King's old fears. Laura's expression looked vacant as she lolled back and forth. She wore away some of the hair on the back of her head. She poked at her ears a lot and scratched them so that her mother found blood on the sheet."

Dr. Brazelton relates these actions to teething by saying, "Playing with an ear or rubbing it is a common accompaniment of teething. Blood in the ear canal may be from a scratch, but it should always be investigated to be sure the drum has not ruptured and the ear is not draining. Place a wad of cotton in the canal. Drainage will continue to wet the cotton. A simple scratch in the canal will not."

One mother described her daughters teething as follows: "She was teething, and when she sprouted two new teeth at once, some of this chewing and rubbing decreased."

According to Dr. Brazelton, "The first two teeth are usually the two lower incisors, and they are followed by the two upper incisors. The first tooth is usually the worst. Perhaps a baby becomes conditioned to his discomfort with later teeth, or else has other resources to turn to by then. Most infants do not mind any but the first incisors and the molars that come at around a year.

Teething patterns are inherited, and whenever there are unusual patterns in their order or timing of appearance, one parent or the other has usually had the same pattern."

The actions of a eleven month old baby detail the process of having the molars come in. "Daniel pulled at his ears a great deal. He dug at them, scratched them so often that his mother was afraid they were infected. She had difficulty attracting his attention at times, and she wondered whether he heard well. However, he was able to hear his father's watch tick with real interest and prolonged concentration. He could hear her whisper, "Do you want a cookie?" from across the room. She realized that his poor hearing was geared to the things he did not want to hear, and that he had excellent hearing when motivation accompanied the stimulus. When she had his ears examined, she was told that they were

normal in appearance. Since he never ran a temperature, and never seemed in the real pain that a child demonstrated when he has infected ears, her doctor assured her that ear-pulling is normal at this age, when molars begin to bother the baby."

Dr. Brazelton gave an explanatory reply to these actions. "A mother can watch for the signs of ear infections: a temperature, tenderness to manipulation of the earlobe, acute pain that does not subside with aspirin, or a discharge from the ear (wax is orange or bright yellow, pus is white and smells foul). A red external ear means very little, as this is a result of rubbing.

Appendix C : Information on Play

The following information is from Play, by Catherine Garvey. In her book, Catherine Garvey shows how child's play can have a systematic and rule-governed nature.

The following is a summary of the information in this appendix:

- Child's play can have a systematic and rule-governed nature to it.
- Childs play is related to growth
  - a) through gaining knowledge and understanding of surroundings,
  - b) through the development of their physical coordination.
- At nine months of age, children are attracted to brighter objects
  - inspects objects (bites it, bangs it, waves it)
- Sex-stereotyped objects are created through parental influence.

The play of children may strike us at times as fragile and charming, rowdy and boisterous, engenuous, just plain silly, or disturbingly perceptive in its portrayals of adult actions and attitudes. If one looks more closely, however, one can discern patterns of amazing regularity and consistency. Child's play has a systematic and rule-governed nature which is, at once, the product and the trace of man's biological heritage and his culture-creating capacity. Play is most frequent in a period of dramatically expanding knowledge of self, the physical and social world, and systems of communication; thus one might expect that play is intricately related to these areas of growth.

What is play? Play is...

(1) Play is pleasurable, enjoyable. Even when not actually accompanied by signs of mirth, it is still positively valued by the player.

(2) Play has no extrinsic goals. Its motivations are instrinic and serve no other objectives. In fact, it is more an enjoyment of means than an effort devoted to some particular end. In utilitarian terms, it is inherently unproductive.

(3) Play is spontaneous and voluntary. It is not obligatory but is freely chosen by the player.

(4) Play involves some active engagement on the part of the player.

Finding out what things are, how they work, and what to do with them occupies a great deal of the attention and efforts of the toddler and the young child. The term "toy" is often given to things that adults have designed or selected specifically to engage a child.

Play with objects serves as a link between the child and his environment in a number of ways. It provides a means by which a child can represent or express his feelings, concerns, or preoccupying interests. They also provide a channel for social interaction with adults or other children. Further, to the child, an unfamiliar object sets up a chain of exploration, familiarization, and eventual understanding: an often-repeated sequence that will eventually lead to more mature conceptions of the properties (shape, texture, size) of the physical world.

Before examining play with objects, one can briefly review the achievements in the first year of life which make such play possible. Some of these accomplishments - the first step, the first word - are noted by parents. Other equally important achievements are seldom remarked, in part perhaps because they emerge gradually. For example, play with objects requires the achievement of visually directed grasping and adequate eye and hand

coordination so that the child can pick up, hold, and turn objects. Such play further depends on the achievement of 'object permanence,' which is the understanding that an object continues to exist even though it is temporarily out of sight. It also requires some differentiation of action patterns, that is, the ability to perform different actions with an objects. And building on the increasing voluntary control of physical movement, a baby develops the ability to repeat an action he has performed previously. More demanding still is the re-creation of an action someone else has performed - that is, imitation.

How Object Play Begins

A composite picture of the changes that take place in a child's encounters with objects over the first three years can be drawn from the recent work of several psychologists. Although the procedures differed among their studies (for example, a child observed at home versus a child seen in laboratory; limited sets of objects presented versus a large group of objects presented), the trends toward more discriminating treatment of objects and greater complexity of object combinations are clear. In the following account, the ages are only approximate - individual children vary, some exhibiting a given type of behavior a bit earlier, some a bit later.

Several miniature objects - a cup, saucer, spoon, hairbrush, truck, trailer, doll - are placed before a child on a table. What is he likely to do? Following, in part, the work of Marianne Lowe , we can predict that:

At *nine months,* the child will grasp a nearer, brighter object and bring it to his mouth; grasp another and do the same. After mouthing the object, he might well wave it or bang it on the table, then inspect it, turn it aroung, and bang it again or return it to his mouth. He uses only a few action patterns.

At *twelve months,* the child is likely to investigate (look at, turn, finger) each object before doing anything else with it. He might then put the spoon in his mouth once or

twice, place it in the cup, and perhaps place the cup on the saucer, but other objects are still treated at random (mouthed, banged, waved).

At *fifteen months,* inspecting and investigating clearly precede other behavior. More and more consistently objects are accorded appropriate, or conventional, uses. The child will place the cup on the saucer and sip from it, and the spoon will be used more deliberately as if he were feeding himself. He will pick up the brush and run it over his hair; next he may push the truck back and forth. He may make the doll stand up.

Toy Preferences

The fact that children are attracted to certain kinds of toys along sex-appropriate line is well known, and some psychologists have considered toy preference as indicative of the child's own sexual identification. Boys consistently choose "masculine" kinds of toys such as soldiers or trucks. Although girls tend to choose dolls and household objects, their interests are generally more versatile. Girls also choose masculine toys, though less consistently than boys do. The origins of these preferences can be traced in large part to parental behavior, to the parents' influence as models and to their approval or support of children's interest in sex-stereotyped objects. A very striking example of even more direct parental control of children's early exposure to types of toys is provided by a study of the private rooms of ninety-six children of upper-middle-class families, in age from under one to six. There was no great differences between the boys' and girls' rooms in respect to the presence of books, furniture, musical objects, and stuffed animals. Boys had more varieties of objects girls did. The boys' rooms contained far more toy animals in barns or zoos, objects relating to space, matter, energy, or time (magnets, puzzles, space ships). The girls' rooms contained more dolls, floral designs on wallpaper and fabrics, adn ruffles or lace. Even though boys' rooms contained some dolls (for instance, cowboys), virtually none represented females or babies.

The most extreme difference was in the number of vehicles owned by the boys' (375) as compared to the girls' (17). No girl at any age had a wagon, bus, motorcycle, boat, or trailer. The typical boy of two had at least three vehicles and by the age of three the average was eleven. Further, only boys had live animals, depots, replicas of heavy equipment, and military toys; only girls had doll's houses, stoves, tea sets, and cradles for dolls. Harriet Rheingold, who directed this study, observes that in her laboratory girls of eighteen months spent as much time playing with trucks as boys did. She concluded that parents were not acceding to the spontaneous interests of their children but were themselves primarily responsible for the extremely different inventories of objects found in the boys' and girls' private rooms. The high-level socioeconomic class in this study might be expected to be less extreme in regard to sex stereotyping than the general population, so that this difference in the toys given to boys and girls is probably quite widespread. Certainly the sex preferences in toys in freely chosen activities in nursery schools, which Margaret Parten remarked on in 1933, are still in evidence today. Boys cluster at the tool bench or push trucks around the room, and girls gather in the kitchen corner to cook and wash dishes in most of the free-activity periods we have observed.

Appendix D: Color Survey

A color survey was conducted at FAO Schwartz toy store to determine the number of times a color was used on a toy. Thirty-five toys were surveyed.

Color	# of times the color was used on a toy
yellow	28
powder blue	5
blue	16
navy blue	5
red	20
lime green	5
green	11
purple	2
pink	6
gray	1
black	3
white	24
orange	10

Top Four Colors most often used on toys:

1. yellow
2. white
3. red
4. blue

Appendix E: Cost Information for Colorants

Cost information for different colors was obtained. The cost of a colorant varies depending on the form, the quantity of colorant ordered, the brightness of the color desired, the transparency of the color, and whether or not a FDA approved color is necessary, an exact price per pound can not be determined. Instead, an estimate was made.

A hypothetical case which fits the characteristics of the present teether was used to determine average prices per pound for each color. It was assumed that an order of 200 lbs is placed for a colorant in the form of ethylene vinyl acetate resin pellets to determine prices for each color.

The following quotes are from a colorant supplier.

Color	$ per pound
white	$2.00
pink	$4.50
red	$5.00
powder blue	$4.00
blue	$4.25
navy blue	$4.50
lime green	$3.75
green	$4.00
yellow	$3.50
orange	$3.60
black	$1.50
purple	$5.25
gray	$2.25

Appendix F: Average Hand Length of a Teething Child

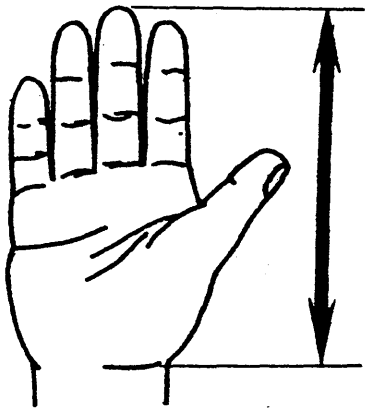
The average hand length of an infant is determined by averaging the hand length of a 3-5 month old infant and that of a 12-15 month old infant. Using data from the chart below which was extracted from the Standard Consumer Safety Specifications on Toy Safety, "American Society for Testing and Materials Designation #963-86", the average hand length was determined as follows:

9.2 - 7.4 = 1.8 1.8 / 2 = .9 .9 + 7.4 = 8.3 cm = 4.25 inches

The average length of children's fingers = optimal width of a teether = (4.25)(.44) = **2 inches**

HAND LENGTH

The infant's right hand is fully extended, palm up. With the paddle blades of an automated sliding caliper, measure the distance from the right wrist crease to the tip of the middle finger parallel to the fingers. An assistant is required to assure that the infant is in the correct position.



HAND LENGTH (cm)
(Males and Females)

Age (mos)	N	Mean	s.d.	Min	5th	50th	95th	Max
0-2	30	6.8	0.6	5.4	5.4	6.6	7.6	7.8
3-5	44	7.4	0.6	6.0	6.1	7.4	8.3	8.5
6-8	30	8.0	0.5	6.9	7.0	8.1	8.6	9.0
9-11	27	8.9	0.6	7.6	7.6	8.9	9.7	10.2
12-15	31	9.2	0.6	7.6	8.0	9.1	10.1	10.8
16-19	29	9.3	0.6	8.0	8.0	9.4	10.0	10.3
20-23	31	9.5	0.6	8.6	8.6	9.4	10.5	10.8

Appendix G: Average Hand Breadth of a Teething Child

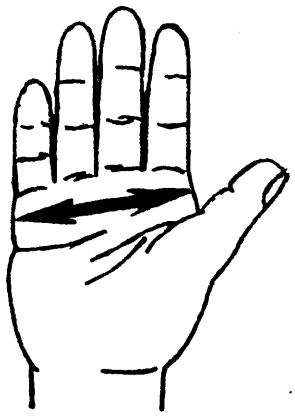
The average hand breadth of an infant is determined by averaging the hand breadth of a 3-5 month old infant and that of a 12-15 month old infant. Using data from the chart below which was extracted from the Standard Consumer Safety Specifications on Toy Safety, "American Society for Testing and Materials Designation #963-86", the average hand breadth was determined as follows:

4.6 - 4.1 = .5 0.5 / 2 = .25 .25 + 4.1 = 4.35 cm = 1.75 inches

The optimal width of a teether = twice the average hand breadth = (1.75)(2) = **3.5 inches**

HAND BREADTH

The infant's right hand is fully extended, palm up, thumb away (abducted) from hand. With the paddle blades of an automated sliding calipher, measure the maximum width across the metacarpal - phalangeal - joint II and V (knuckles). An assistant is required to assure that the infant is in the correct position.



HAND BREADTH (cm)
(Males and Females)

Age (mos)	N	Mean	s.d.	Min	5th	50th	95th	Max
0-2	31	3.7	0.3	3.2	3.2	3.6	4.2	4.4
3-5	44	4.1	0.3	3.3	3.5	4.0	4.4	4.6
6-8	30	4.2	0.2	3.8	3.8	4.1	4.5	4.7
9-11	27	4.5	0.2	4.0	4.0	4.4	4.8	4.9
12-15	30	4.6	0.3	4.0	4.0	4.5	5.0	5.1
16-19	29	4.6	0.3	4.1	4.1	4.5	5.1	5.3
20-23	31	4.7	0.3	4.1	4.2	4.6	5.2	5.6

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