SafeShell

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Section 24, Team 2

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Executive Summary

Problem: Currently, baby swings are the prevalent method of calming fussy babies. These swings, however, are potential hazards to infants because of two main design flaws: the misuse of straps, which can strangle the baby, and the tipping of the seat, which can cause the baby to fall out. Our client, Ms. Nancy Cowles of the Kids in Danger Foundation, has tasked us with developing a safer way to calm fussy infants.

Requirements: Our design must incorporate a safe way of calming fussy babies, that is (1) feasible for parents to use, (2) effective in soothing infants, and (3) economically viable to be constructed.

Design Process: After comprehensive observation and background research, we resolved these requirements through a two-pronged approach: (1) develop a spherical seat, which will minimize the chance of an infant falling out of the design, and (2) feature a blanket-harness hybrid system that provides the security of a five point harness with fewer straps, which reduces entanglements.

Design Overview: The *SafeShell*'s spherical seat will be 32 inches in diameter, and be constructed from plastic. The interior will be padded and covered with a cotton exterior for comfort. The harness will feature a blanket for the torso, and two straps for the shoulders. This reduced strap design will reduce the likelihood of entanglements.

Deliverable: We will deliver to our client a working prototype that will display the key functionalities of our product.

Figure 1.1: exterior of the Safeshell

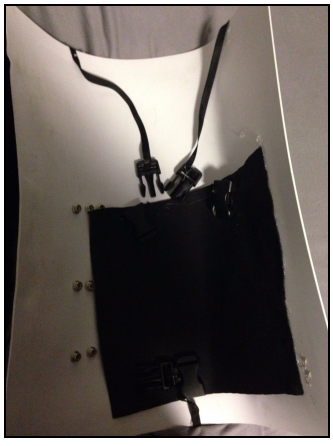


Figure 1.2: Harness system

Introduction

Our client, Ms. Nancy Cowles of the Kids in Danger Foundation, has tasked us with developing a safe way to calm fussy infants. Currently, baby swings are the prevalent method of calming babies, which includes soothing loud or crying infants, as well as rocking infants to sleep. These swings, however, are potential hazards to infants because of two main design flaws: the misuse of straps, which can strangle the baby, and the tipping of the seat, which can cause the baby to fall out. In 2011 alone, these flaws accounted for roughly 1900 infant swing related injuries according to hospital reports. Our design, the *SafeShell*, specifically targets these two issues, resolving the hazards of typical baby swings.

Principally, *SafeShell* decreases the likelihood of the infants falling out of the seat portion of the infant swing. Furthermore, the design addresses the issue of infant entanglement seen in many overly complex fastening systems.

Based on our research and observations, we designed the *SafeShell* to tackle the problem of calming fussy babies in a two-pronged solution: (1) develop a spherical seat, which will minimize the chance of an infant falling out of the design, and (2) feature blanket-harness hybrid system that provides the same security of a five point harness with fewer straps. In the future, we would like to add a guard rail system that stabilizes the motion of the *SafeShell* as it swings.

This report specifies the features, usage, and possible benefits of the *SafeShell* along with presenting the users and requirements, research conducted, and the problems encountered in the design process.

Users and Requirements

When dealing with products and designs that are intended to be used with infants, there are multiple direct users (infants) and indirect users (parents, caretakers, etc…) involved, and specific requirements that must be addressed for each. This is discussed further below.

Users:

(1) Infants up to the age of 6 months:

This product is designed to be used with infants ranging in age from 0 to 6 months old. Naturally, infants' moods are volatile, and need assistance to be calmed down.

(2) Adults responsible for looking after children (parents, guardians, babysitters, etc):

The responsible adult(s), which in most cases are parents, are most likely the ones who will buy the actual product to use with their infant(s) when the infant becomes fussy. Parents are the ones who actually interact and control the product, and what they need from our product is something safe and effective to relax the distressed child. In many cases, these parents are occupied with other responsibilities, and rather than trying to balance many tasks, they would rather have a swing calm the baby, and then be able attend to other tasks.

(3) Nancy Cowles & Kids in Danger:

Kids in danger is an organization devoted to ensuring that products used by small children are as safe as possible, and Nancy Cowles serves as the executive director. Mrs. Cowles has many connections with designers and manufacturers, and may use our design concepts in her work to continue furthering the safety of children. She could do this by implementing the best parts of our designs into future designs that may enter the marketplace.

(4) Consumer Product Safety Commission (CPSC):

The CPSC is concerned with protecting consumers and families from dangers associated with using many consumer products in the United States. Any design that might be released onto the market in the United States must meet the relevant CPSC standards.

Requirements:

(1) Safety

- Weight:
  Since the average 6 month old weighs around 17 pounds, the infant swing should be able to safely hang at least 50 pounds of weight without the risk of the seat breaking. This is to minimize any risk that from by external forces, such as an older sibling leaning on the swing.

- Harnesses:
  The harnesses of infant swings are the component responsible for causing the most injuries and deaths. The harness need to securely fasten the infant in the seat while still allowing their limbs to move relatively freely. Additionally, the chance of children slipping through the harness straps needs to be eliminated because this can lead to entanglement, falling out, seat tipping, and other hazards.

- Swinging Motion:
  The *SafeShell* needs to incorporate swinging motion for it to be effective, but this motion can be dangerous if the range of motion is not restricted. From our research, the swing should not swing higher than 35 degrees in any direction.

(2) Functionality:

The swing needs to enable parents to put their children down for a period of time without putting the child's safety at risk, although the parent should still be present during swing usage. The swing needs to incorporate a smooth rhythmic motion that babies typically find appealing, which is usually accomplished with a small electric motor, and the seat needs to be made with comfortable materials to help the infant relax.

(3) Size:

Although there isn't a specific size requirement for this product, it needs to be of a "practical" size in order for it to be appealing to customers. Considering that most users will use an infant swing indoors, the swing cannot be so large that it takes up most of a typical room's floor space. A target size for the floor space the swing should require is around 1m by 1m.

Design Concept and Rationale

The *SafeShell* will decrease the chance of entanglements as well as significantly lower the number of infants falling out of the swing. This fulfills our client's requirements for the design of creating a safer swing. The *SafeShell* tackles these safety concerns and restraint issues through the implementation of these main features:

- A spherically shaped infant seat with a section cut out, as specified below in figure 2.1
- A fabric lining inside filled with a plush microfiber
- An adjustable fabric strapping system with an additional three point harness attached

The spherical shape surrounds the infant with curved walls. This ensures that infants will not fall out the swing if they lean forward, and also hinders larger infants from climbing out of the swing. The strapping system, moreover, provides the same level of safety of a five-point harness system, but uses two fewer straps. By having fewer straps, there is less of a chance that the infant will become entangled in the strapping portion of the design. Through our two strap system, coupled with our curved wall design, *SafeShell* reduces seat tipping and infant entanglements. The precise features of each design is laid out below.

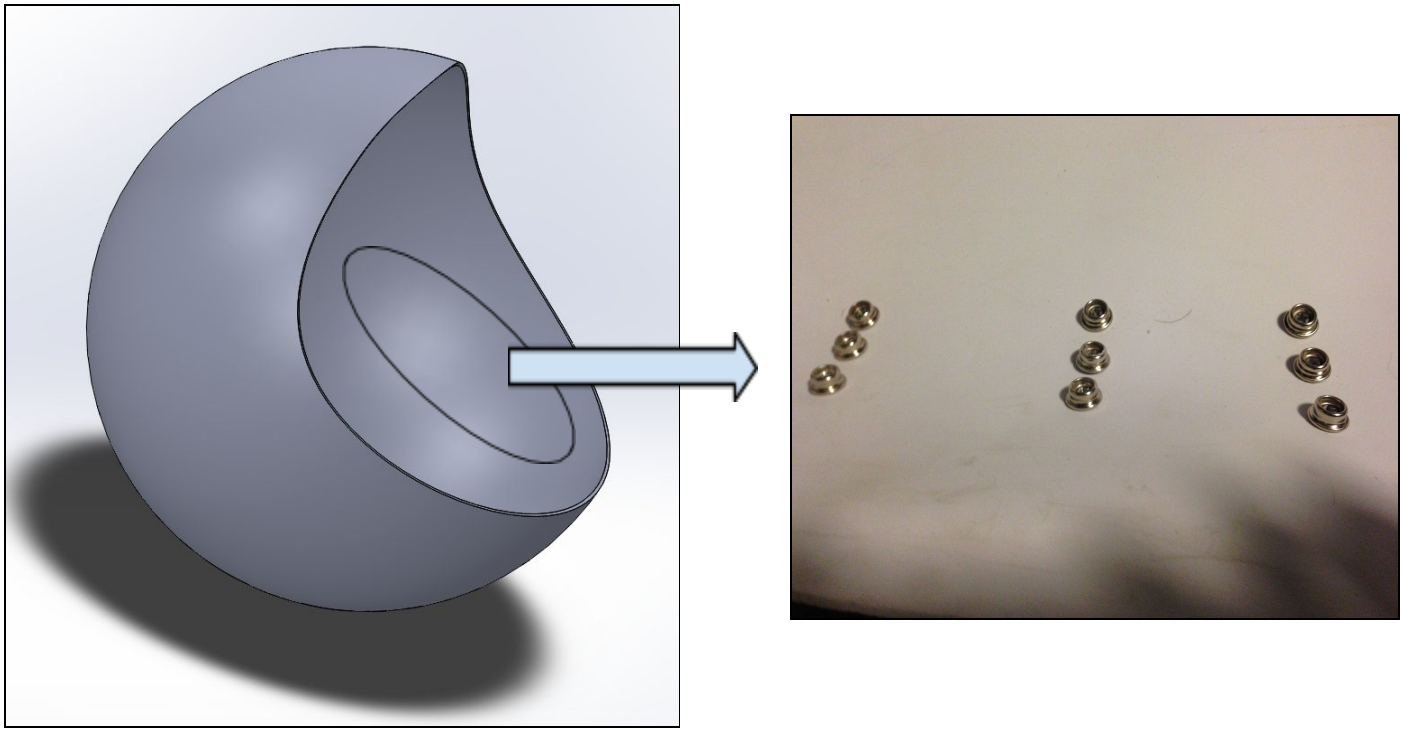
Figure 2.1: Front view of the SafeShell

Design Features

<u>Spherical Seat</u>

The seat itself is modeled in the shape of a sphere, and was designed using the computer-aided design (CAD) program, Solidworks. It was then constructed with the aid of a 3D printer, incorporating walls 0.1 inches thick (this was in order to ensure stability, but minimize materials and thus cost). For our prototype, the printer could only produce a model of four inches in spherical diameter. Ideally, we would like the outer the shell of the sphere to be 1 inch thick and have a spherical diameter of 32 inches. A shell with a 1 inch thickness would enable ¾ inch male end fabric snaps into the designated areas for the strapping system, as shown in figure 2.2. A 32 inch spherical diameter would be ideal because the largest infants in our product will 27 inches tall. Considering a recline of roughly 40 degrees, the very largest infants would assume 24 inches of horizontal space in the sphere. By having a spherical diameter of 32 inches, this leaves 4 inches on both the front and back ends of the infant, which is ample amount of extra space.

Figure 2.2: CAD drawing of the sphere seat and designated areas for fabric snaps



Often, infant swings have toys that hang from the top of the seat. Stickers and other adhesive toys can be placed on the overhang portion of the *SafeShell* that hangs above the child's head. Furthermore, the opaque backside of sphere provides extra security against flying projectiles. This could be a helpful barrier and

further protect the infant. For instance, if another child were to throw a tennis ball at the backside of the swing, the ball will simply bounce off, and the baby will not be disturbed. However, if there was no backside over the baby, the ball could hit the baby, waking up the infant and possibly injuring him or her.

Fabric Lining

The inside of the sphere is lined with thin cotton exterior, which covers a plush microfiber padding. The microfiber distributed to each section will vary in order to create a 40 degree angle with the ground, as shown in figure 2.3. Based on our research, angles 45 degrees and higher can be dangerous, as the baby can slouch over and hurt his or her back (CPSC, “Safety Standard for Infant Swings”). By reclining at a 40 degree angle along with a harness system, there is no possibility of an infant learning out of the seat. In a future version of our design, this lining will be sewn into the sphere with Kevlar thread and screwed into the walls (possibly with plastic nails).

Figure 2.3: Inside lining of the SafeShell

Harness System

The first piece of harness system is the “blanket”. In our prototype, we are using a piece of cotton that is 10 inches long as the fabric. One end of the cotton is attached to the sphere, as shown below. This side will not be able to be adjusted. The other end of the cotton has three female portions of fabric snaps attached to it. These fabric snaps are attached to the male portion of the fabric snaps, which are on the other end of the sphere. There are three sets of fabric snaps, which allows the parent to adjust the fabric to be the correct size for the infant. Ideally, the fabric would be made out of a microfiber, polyester fabric. This material has higher elasticity along with being a more breathable fabric, which are optimal features for our product.

Figures 2.4: Attached portion of the fabric and adjustable end of the fabric

The second feature of our harness is the three strap system, in which one strap passes by the crotch area and links with two shoulder straps. The straps themselves are made from highly tensile nylon. Each end of the shoulder straps is attached to the inside of the sphere with nails. For the crotch strap, one end is attached to the bottom part of lining, as seen in the figure 2.5. The straps themselves are adjustable to meet the size of the infant. The male ends of the buckles are attached to the straps, while the female ends are attached to the “blanket”, as shown the right hand image of figure 5.2. If we had more time, we would build a single female buckle for both of the male ends of the shoulder straps to connect, but for the sake of simplicity, the female ends of the shoulder straps are separated.

Figures 2.5: The strapping system

Benefits

The *SafeShell* provides an infant swing with several safety benefits that the standard infant swing seat does not provide. Principally, the *SafeShell* prevents infants from falling out of the swing. Our research [Appendix 2] shows that the largest amount of injuries from infant swings are infants falling out of the seat. By placing a spherical wall around the infant, he or she will not be able to lean forward and fall out of the seat. Furthermore, as established before, the curved walls of a sphere make it very hard for an older infant to crawl out of the design even without the harness system.

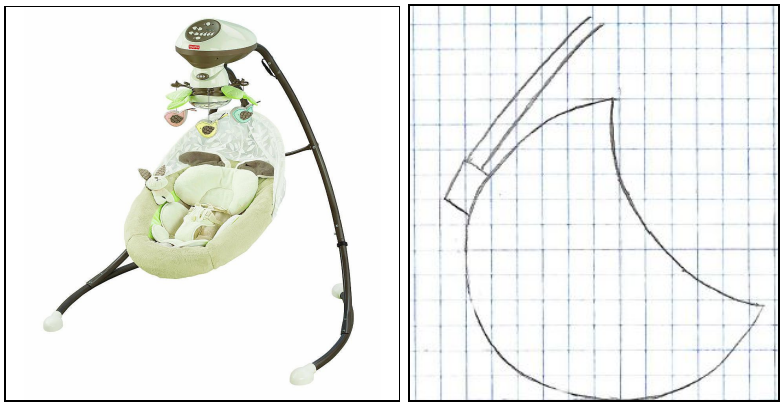
The *SafeShell* also reduces the risk of the infant becoming entangled in the harness system. Our design replaces the two side straps of a five-point harness with a thin, breathable fabric that still keeps the child securely in the seat. Since two of the straps are replaced with the fabric, there are only three straps needed. The fewer amount of straps lowers the ability of a child becoming entangled. Additionally, the fabric serves as a blanket, which is much more comfortable than the typical three point harness.

The harness system is also completely adjustable, which means that the *SafeShell* can be used for any infant. Moreover, the elasticity of the polyester microfiber material allows the blanket to be stretched any of three of the settings without a problem.

Lastly, the shape of the sphere decreases the chance of objects from the outside world flying into the seat and hitting the infant. If the object (ball, block, etc.) lands anywhere other than upper opening of the sphere, it will simply deflect off the sturdy, plastic outside of the *SafeShell* and not affect the infant.

Use

The *SafeShell* can easily be implemented by several different manufacturers. Most large-end infant swing manufacturers use the model with the motor on the top of the swing, with one connection point, as seen below to the left. We propose that the *SafeShell* can be attached in the same way, with a pole attached to the back of the sphere (figure 2.6).



Figures 2.6: Motor on top of the swing and proposed way of attaching the pole

Future Development

Although we have made significant advancements in generating a final design of the *SafeShell*, there still are several components that could be improved upon. In this section, these areas will be discussed along with the provision of possible ways of approaching these issues.

Collapsibility

The largest area of improvement of our design its size. In order to comfortably seat infants of the ages of 0 to 6 months, the size of *SafeShell* should have a 32 inch spherical diameter, which suggests that the diameter at all given points of the structure are 2.33 feet. To get a seat of this size through most doors will be tricky. Therefore, if future development is conducted, there should be an attempt to make the upper portion of the collapse or at least be able to be separated from the bottom. One of our solutions is to create the seat in two separate parts that could be snapped together at several different locations. Another possibility is cut off the top half of the sphere, leaving only the bottom hemisphere. Although this would halve the length, it would reduce the *SafeShell*'s ability to prevent external projectiles from hitting the infant.

Implementation of a Pole

Our design leaves out the connection of the *SafeShell* to the motor, and future development could allow to us build a connection to a motor. As stated under the "Use" section of the design concept and rationale, we plan on connecting the *SafeShell* to the motor via a pole in the back. The force exerted on the motor will cause the *SafeShell* to rotate. To create this pole, we would create pole holder in the back of the design, as seen in the figure 2.6. The pole would then be attached to the pole holder (possibly by welding) while also being connected to the motor at the other end.

A Fluid Adjusting of the “Blanket”

Another possible improvement would be to change the method of adjusting the tightness of the “blanket”, or the fabric that acts as the two side straps. At the moment, there are set points where the fabric straps can connect. It would be more optimal if there were not set points of connection, but instead if there the blanket could be adjusted to any given tightness. A possible way of approaching this would be to utilize how straps such as the ones below can be adjusted by the mechanism at the bottom of each strap. If we could apply this to whole length of the fabric, it could be adjusted to any given length

Figure 3.1: Adjustable strap mechanism

Shape of the Shell

After further discussion with the group and professors, we have decided that it would be more viable to change the shape of the shell from a sphere into an ellipsoid in the future. This is due to the fact that the sphere creates a large amounts of extra space on the sides of the baby. If we use an ellipsoid shape (a 3D oval), we can minimize the amount of material needed while also reducing the size of the design.

Guard Rails

Our ultimate design will include a set of guard rails that will attach to the sides of the *SafeShell*. The motion of the seat will be along these rails, and therefore, the rails will ensure

that the swing never tips. The rails will be constructed from steel, and be attached to a plastic base to support the rails.

Since the rails will provide invaluable added safety to the *SafeShell* system, we plan to design a guard-rail system that will not only be usable for the *SafeShell*, but also able to be installed on all pre-existing swings.

Conclusion

The *SafeShell* is designed tackle the main design flaws of pre existing infant swings. These two main hazards are (1) the misuse of straps, which can strangle the baby, and the (2) the tipping of the seat, which can cause the baby to fall out. We have developed a two-pronged approach to addressing these flaws: (1) develop a spherical seat, which will minimize the chance of an infant falling out of the design, (2) feature blanket-harness hybrid system that provides the same security of a 5 point harness with fewer straps. In the future, we would like to add the guard rail system to stabilizes our design.

Our client, Ms. Nancy Cowles of the Kids in Danger Foundation, has tasked us with developing a safe way to calm fussy infants. *SafeShell* decreases the likelihood of the infants falling out of the seat portion of the infant swing, as well as resolves the problem of infant entanglement as seen in many overly complex fastening systems. Even though there is room for future development, these features meet the requirements of our client, and provide her with a deliverable prototype which she can alleviate the dangers of current infant swings,

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Appendices

I. Project Definition

Mission Statement: To design a seat for an infant swing that minimizes the possibility of restraint-related injuries.

Project Deliverables:

- A theoretical idea for an infant calming device and a prototype of this idea
- A final report describing the function and design of the idea

Constraints:

- Must cost $100 or less
- Needs to follow the CPSC & ASTM rules and regulations for infant swing seats

Users and Stakeholders:

- Infants of the ages of 6 months or less
- Parents, babysitters, and anyone else who will look over children for hours on end
- Nancy Cowles, our client
- The Kids in Danger organization
- CPSC

Requirements	Specifications
Safety ● Prevents the child from falling out of the device ● securely straps the infants into the device	● the bottom "lip" of the sphere has a hight of 5 inches from the bottom of the design ● child cannot move more than 2 inches in the harness system
Calming Function ● Reduces the heart rate of the child and allows the infant to relax ● child must be comfortable in the swing	● 15 inches of the inside are lined with plush materials
Structure ● Allow for infants from 0-6 months of	● no taller than 30 inches ● can support from 9 to 20 pounds

age to be supported in the device ● Not permit infants to leave the design ● Maximizes space efficiency	
Maintenance/Durability ● Able to be cleaned ● Can be transported	● materials used are waterproof ● the device can be washed with a damp cloth or disinfectant wipe ● the device can fit through a door with the dimensions 30 by 30

II. Background Research Materials

Initially, we conducted research into infant swings, the area designated by our client, a representative of the Kids in Danger organization. She approached us with the problem of minimizing the amount of dangers of infant swings. These devices often have several safety issues for children, as it can be very easy for one to become entangled in the straps or to fall out of the seat.

The main aspects of our research are:

1. How an infant swing functions and calms down a fussy baby
2. The hazards of the infant swings and the effects of these hazards on the children
3. Current infant swings already on the market

Function of the Infant Swing

Infant swings are devices that are designed to calm fussy children. The main components of an infant swing include a frame with a built-in motor and a seat for the child to relax inside. The seat and frame are usually connected at 1-2 connection points. At these points, the power transmitting from the electric motor to these points causes the seat to rotate. Infant swings can either have back-and-forth or side-to-side movement.

Figure 4.1: Two types of connections

The seat is often created from a sturdy plastic. It is also created at a curve, as the end where the head lies often has roughly a 45 degree angle from the ground. The end where the feet lie often have a smaller angle than that of the other end. To provide the child with comfort, the inside of the seat is lined with some type of plush material. Furthermore, most infant swings also use a five point strapping system that will keep the child secure in the seat. There are often toys dangling above the infant that are attached to the frame of the design.

Figure 4.2: Seat angle and 5 point harness

There has not been much research conducted in the field of how infant swings calm a child. Some studies have shown that infant swings imitate the very gentle, rocking motion of a parent rocking his or her baby in his or her arms. This rocking motion has been thought to imitate the motion of an infant in the womb of the mother ("Baby Swing Buying Guide"). Further research in psychology has shown that the proprioception, or the infant's ability to sense body motion, makes the rocking motion a pleasurable stimulus. The infant swing also affects the parasympathetic nervous system and lowers the heart rate of the user (Esposito, Gianluca "Infant Calming Responses during Maternal Carrying in Humans and Mice"). The noise of the system as it swings back and forth is often very relaxing for the child.

Hazards

Many dangers have been associated with infant swings. The CPSC reported that there are roughly 1900 injuries related to infant swings every single year. 42 percent of all injuries are restraint-related issues, which is the largest percentage. Numerous infant swings cannot handle moments when distribute all their weight to one side of the seat. This can cause the seat to either snap off the frame. Moreover, there also several instances where the child leans forwards or sideways; this could lead to child falling out the seat. Children falling out the seat amounts for 78% of infant injuries in swings, the most frequent type of injury (CSPC, "Safety Standard for Infant Swings"). A less frequent scenario which arises from restraint-related issues is when an infant puts a large amount of force on the end of the seat where the head rests. This

has resulted in instances where the swing will tip over, and the infants almost always land on their heads.

Another main issue is the strapping system of the device. Failed strapping systems have lead to fatal situations for some infants. An example of the dangers of these strapping systems would be Trevor, a kid mentioned on the Kids In Danger website. Trevor was in an 8 month old infant swing for extended period of time by himself. During this time, he became entangled in loosely attached shoulder harnesses and sadly perished. There have been at least 4 other infant deaths due to strap malfunctions (Staci and Greg, “Trevor”).

There are other hazards that are less prominent than the two mentioned above. Toys that are attached to the frame can fall and land on the infant. Poorly designed infant swings have held certain cushions break off the seat, providing discomfort to the child. The seat can also fold up while the child is in the swing.

Products on the Market

Infant swings are a fairly commonplace item on the market directed towards new parents. Every year, roughly 2.7 million swings are purchased in America alone. This section will focus on a successful design, the Fisher-Price Cradle’n Swing, and a failed one, the Century Lil Napper. By examining these successful and unsuccessful products, we can deduce certain aspects of the designs that result in failure or success and possibly implement successful aspects into our design.

Parents on the internet consider the Fisher-Price Cradle’n Swing to be one of the best products on the market. One of the aspects that sets apart this design is its functionality, as there are several options to the design. The swing has a central point of rotation that is above the seat. Furthermore, the seat can be detached from the rotation point and reattached in several directions. This allows the design to have back-and-forth along with side-to-side motion by simply changing the direction of the seat. The Cradle’n Swing can also play music and has adjustable levels for the speed of that the seat rotates. The downsides to the design is that it can only be used for very young infants. The product has a developmental guideline that suggests that the infant can no longer use the swing once they have the ability to crawl out of the seat. Fischer-Price has a very small yet comfortable strap that only covers the pelvic area. Once the baby can crawl, there is no chance that this strap will keep the infant in the seat.

Figure 4.3: Cradle'n Swing

On the other hand, the Century Lil Napper has not received favorable reviews. This is the same design where Trevor (the child previously mentioned in the hazards section) became entangled in the straps and perished. The Lil Napper has two shoulder straps that run from the shoulders to the area between the legs. There are also a strap around the chest area that connects the two shoulder straps. The combination of the two shoulder straps along the connection strap have the ability to strangle an infant. Also, the design uses thin bars to support the system. Although these bars seem easy to assemble, they are not incredibly sturdy and make the system take up a large portion of space.

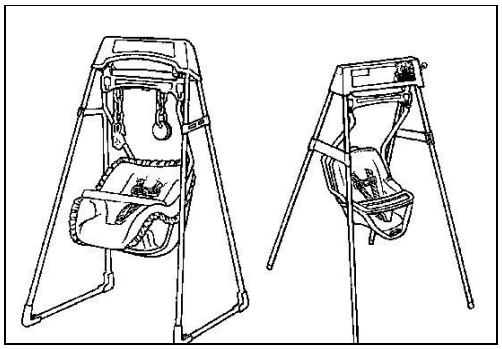

Figure 4.4: Century Lil Napper

III. User Observation Results

Because we were unable to observe actual parents/guardians using infant swings with their children, we performed our user observation by going to a Babies 'R' Us store (4/20/2015) in order to interact with real swings on the market in person. Based on previous conversations with our client (Nancy Cowles), we knew two main dangers associated with infant swings to be how easily they can tip over and the possibility of infants slipping through the straps and getting choked by them.

Upon visiting Babies ‘R’ Us and getting an up close look at the different swings on display, the dangers that our client had informed us about became very evident. After seeing the results of our research reflected in the products we were examining, we decided to pursue creating a design that would primarily address the issues of swings tipping over and harnesses becoming dangerous.

Below are some photos taken on our visit that attempt to demonstrate the shortcomings we would later focus on improving.

Figure 4.5: Shortcomings of standard infant swings