The Cinderella Project

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Cinderella – Modern Parity

At the stroke of midnight, Cinderella realized she must go. She raced down the long castle staircase. "Don't fall, don't trip," she kept repeating to herself. Oh, how fun it was to dance with a prince, a real prince. But, oh, how her feet hurt. Was this the true price of beauty? Just as she realized the impossibility of running in glass high heels, one hung on a crack in the step. As the clock kept clanging, she quickly removed the other shoe and raced on into the night.

Once upon a time…

The Cinderella Project grew from a shoe project done in the World Images of Science and Engineering for Women (WISE Women) summer program at Mississippi State University. The original project used cardstock, glue, and other materials to construct a model tennis shoe. However, the girls would often construct sandals, wedges or heeled shoes. The not so revolutionary discovery was that girls are interested in girls' shoes. In a discussion with those involved with outreach to girls and women, it was decided that a whole project could be built around this concept of creating engineering activities specifically for girls.

This is based on the first principle of C. Rogers' experiential learning theory, which is: "Significant learning takes place when the subject matter is relevant to the personal interests of the student" [1]. Therefore, engineering outreach activities that are designed for girls will be more effective in attracting them to the field of engineering.

Who decided that shoes were cool?

Shoes are such an important part of our history that several American museums have hosted shoe exhibits. France, Germany, and Canada even have shoe museums. Early civilizations recognized the importance of protecting feet against jagged rocks, burning sand, and rugged terrain. Records of the Egyptians, the Chinese and even the Bible contain references to shoes. The first shoes were a simple piece of plaited grass or rawhide strapped to the feet. Among the relics of early Egyptians are some beautiful sandals made from plaited papyrus leaves.

When the medieval guilds controlled craftsmanship in Europe, perfection in workmanship and extravagance in style seems to have been sought in shoes rather than foot comfort and protection. As last as 1850, most shoes had the same shape for the right and left shoe. Also, only two widths of size were available: a "slim" shoe and a "stout" shoe. Through all this development, comparatively little attention was devoted to fitting qualities or comfort [2].

The 20th century saw major advancements in the comfort and design of shoes. Rubber discovered by Charles Goodyear in the 19th century was used to make major advancements in comfort. In 1964, Bill Bowerman and Phil Knight formed the running shoe giant, Nike. In 1972, Bowerman developed an optimal traction sole by shaping rubber in a waffle iron. His other footwear inventions were the running shoe wedged heel, cushioned mid-sole, and nylon uppers. In 1992, Ingeborg Fusaro patented her Shock Absorbing Heel, which is used by many designers to provide comfortable business and dress shoes for both men and women [3].

At the present time, millions of dollars are spent each year on the marketing and design of footwear. Although "cool" designs and extravagant shoes are still a primary part of the shoe industry, the public is increasingly interested in the comfort of their footwear.

Oh, my aching feet…

Pressure is a measure of force applied over a given area. This basic physics concept becomes very important in the design of shoes. The problem becomes more complicated by the action of walking, called the Gait Cycle. The three steps of the Gait Cycle are: the Contact Phase, the Midstance Phase, and the Propulsive Phase. Pressure changes as the foot goes through the Gait Cycle. During the Contact Phase, the foot lands on the heel and the strain is taken up by the Calcaneus (heel bone). During the Midstance Phase, your weight shifts forward and the force goes away from the hell and toward the midsection of the foot. During the Propulsive Phase, the foot continues to roll forward, the force exerted onto metatarsal bones and can be between four to seven times the body weight. Shoes must properly address these changes in pressure to yield the greatest comfort and protection for feet.

Although many women are dissatisfied with their dress shoes because they hurt their feet, they are still wearing these shoes. Women have about 90 percent of the nearly 800,000 surgeries for foot afflictions. The use of these high heels, along with poorly fitting shoes, foot abuse, or other mistreatment of the foot cause a number of foot afflictions to women. There is a direct link between the type of shoes women wear and the development of foot afflictions. These afflictions include Achilles tendonitis, bunions, hammertoes, metatarsalgia, neuromas, plantar fasciitis, and pump bump.

The first condition, Achilles tendonitis, is the inflammation of the Achilles tendon. Wearing high heels can shorten the tendons causing tendonitis. Not appropriately warming up for vigorous physical activity can also cause tendonitis.

Bunions are misaligned big toe joints that become inflamed and tender. Wearing shoes that are too narrow in the forefoot and toe, such as high heels, causes bunions.

The next foot affliction to women, hammertoe, is a condition where the toes are contracted in a claw-like position. This condition usually comes from a muscle imbalance, but can also be irritated by ill-fitting shoes that cramp the toes.

Neuromas is enlarged, benign growth of nerves, most commonly between the third and fourth toes. The inflammation and fibrosis resulting from this growth of nerves can diminish both

nerve and vascular flow, resulting in a burning, pain, tingling or numbness that can extend to the toes. Treatment for neuromas can include orthotic devices, steroid injections, and possibly surgery.

Plantar fasciitis is the inflammation of the long band of tissue running from the heel to the ball of the foot, the main cause of foot pain. Wearing shoes that cramp the feet in the arch area, like high heels causes this condition.

The last condition, pump bump, also called Haglund's deformity, is a bone expansion at the rear of the heel bone, where the Achilles' tendon attaches to the bone. This is the result of faulty biomechanics causing increased motion of the heel bone against the shoe counter.

Conclusion

If women do not start to pay more attention to comfort of the shoes they wear and less attention to the fashionable, uncomfortable shoes, there will be more and more foot afflictions associated with women. However, there is now a more sensible solution, which is also fashionable. Custom-made shoes are now available that combine fit, fashion and the postural support of custom orthotics.

So, what do we do now?

Knowing what we know about the problems associated with women's feet and how important it is for women to have stylish, yet comfortable shoes, we need to teach the engineers of tomorrow how to design a comfortable, yet, stylish shoe. So, the Cinderella Project is one way for future engineers to learn the engineering design process and have fun at the same time.

The Project Itself

The Cinderella Project has four parts:

1. Measurement of Feet – In this part of the project, students are instructed to measure their feet. Some may find that it is hard to categorize their feet into one size. Also, they learn some people have feet that are two different sizes.
2. Design of shoe sole and upper – This part of the activity consists of looking at the pressure exerted by different points of the foot. Comfort and style must also be considered in the design. Students are instructed in the engineering design process.
3. Construction of shoe – Students construct their shoe based on their design. Often they are surprised at the redesign that has to be done.
4. Marketing of the shoe –Student must create a marketing plan for their shoes and sell their shoes.

Measure Your Feet

Don't know your shoe size? Your feet change during your lifetime. To make sure that you get the best possible fit and comfort, you should measure your feet using the following method:

1. Place a piece of blank paper on a hard floor.

2. Stand on the paper wearing a sock of medium thickness.
3. Holding a pencil vertically, place a mark at the end of your heel.
4. Place another mark at the tip of your longest toe.
5. Mark the sides of your foot at the widest part.
6. Measure your other foot using the same method.
7. To find your size, measure the heel-to-toe mark and use the inch-to-size table. For example, if you are a women and your foot measures 9" long, you will wear a U.S. size 6 shoe.
8. To find your width, measure the marks for the widest part of your foot and use the inch-to-size table. For example, if you are a woman with a U.S. size 8 length and your width measures 3-5/8", you will wear a medium width (B) shoe.
9. If your measurements are between two sizes, or you find one foot's measurement larger than the other, always move up to the larger size [4].

Table 1. Dexter Size Chart. [4]

Women's Inch to Size Chart					
Heel to toe Length (In inches)	Size (USA)	Narrow Width (AA) for this Size	Medium Width (B) for this Size	Wide Width (D) for this Size	Extra Wide Width (EE) for this Size
8 11/16	= size 5	2 13/16	3 3/16	3 9/16	3 15/16
8 13/16	= size 5 1/2	2 7/8	3 1/4	3 5/8	4
9	= size 6	2 15/16	3 5/16	3 11/16	4 1/16
9 3/16	= size 6 1/2	3	3 3/8	3 3/4	4 1/8
9 5/16	= size 7	3 1/16	3 7/16	3 13/16	4 3/16
9 1/2	= size 7 1/2	3 1/8	3 1/2	3 7/8	4 1/4
9 11/16	= size 8	3 3/16	3 9/16	3 15/16	4 5/16
9 13/16	= size 8 1/2	3 1/4	3 5/8	4	4 3/8
10	= size 9	3 5/16	3 11/16	4 1/16	4 7/16
10 3/16	= size 9 1/2	3 3/8	3 3/4	4 1/8	4 1/2
10 5/16	= size 10	3 7/16	3 13/16	4 3/16	4 9/16
10 1/2	= size 10 1/2	3 1/2	3 7/8	4 1/4	4 5/8
10 11/16	= size 11	3 9/16	3 15/16	4 5/16	4 11/16
10 13/16	= size 11 1/2	3 5/8	4	4 3/8	4 3/4
11	= size 12	3 11/16	4 1/16	4 7/16	4 13/16

Design of Shoe Sole and Upper

The main objective of this project is to design and make a pair of prototype sandals from Checkcard™ using the engineering design process. The process steps for this project are:

1. Customer need or opportunity – a stylish, yet comfortable shoe.

2. Problem definition – shoes are to hold the weight of at least one person, and must incorporate biomechanics of foot.
3. Data and information collection – history of shoes and biomechanical problems of women's feet.
4. Development of alternative designs – different types of polygons are used for bottom of shoe and various materials are examined for comfort of foot inside shoe.
5. Selection of optimal design – based on performance of different types of polygons, students choose the best and strongest shape.
6. Implementation of optimal design – students choose and create best shape for support and comfortableness.

The materials needed are: Checkcard™, hot glue gun and sticks, scissors, X-Acto knife, straight edge, pencils, and other materials (new or recycled) to make and decorate upper part of shoe.

Construction of Shoe

Prismatic cells are used to construct the sole of the shoe. A prism is any shape that can be made as an extrusion. Polygons, if extended upward off the page will create a prism. First, the students (in teams of one or two) should cut out 1"x 4" pieces of Checkcard™ and make them into prisms with an overlap of ¼". These prisms are left open at the ends. After cutting the strips, the students can experiment with any kind of polygon. The students can then test the strength of different prisms by loading them with books.

After figuring out which is the strongest polygon, the students then trace around the foot of one partner on the Checkcard™ to create a pattern for the sole of the shoe. This is the part that will be in contact with the foot.

Before designing the bottom of the shoe, the students should determine which part of the foot has the most pressure. To do this, use a box of wet sand. After stepping in the sand, the students can see by the depth of the indention in the sand where the most pressure is located. (This can also be done by wetting the bottom of the foot and placing it on a piece of construction paper.)

Students then design a prism shape based on what they believe to be the strongest and construct their prismatic cells. Using the hot glue, the prismatic cells are attached to the foot silhouette [5]. Placement is based on comfort, support and styling.

Students make and decorate the upper of their shoe based on the function of they have chosen for their shoe. The upper is then attached to the sole of the shoe. The shoes themselves are judged based on the following criteria:

1. Comfort and good fit
2. Appearance
3. Wear ability (stays on, stays together and comfortable over a period of time)
4. Structural support of weight at least one inch from the floor

5. Support location customized to pressure points
6. Integration of components (sole, upper, insole)
7. Geometric cell construction (each cell can be only one thickness of paper).

Marketing of Shoe

To market the shoe, the students must first research advertisements for shoes. They look at television, magazines and internet. After researching types of ads, the students then create an "ad" of their own. Once they have their ad, they must then "sell" their shoe. They survey the other participants of the program and/or college students (on the "street" or a class of students – marketing, education, etc.). The students can either price their shoe before or after surveying the students. "Do you like this shoe?" " Would you buy this shoe?" "How much would you pay for this shoe?" are some of the survey questions. Once the results are tabulated, students then create a presentation to a panel of judges. The presentation must include the results from the survey, how the biomechanics of the foot are incorporated, and their "ads." The students are judged on the shoe (75%) and their presentations (25%). And the winners live happily ever after….

References

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