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Design for All



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Center for Universal Design

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EDITORIAL FORWARD

I was given the honor by Dr. Sunil Bhatia, Design For All Institute of India, to pay tribute to Ron Mace in this issue of Design for All. As a recipient of this newsletter you are familiar with and motivated by 'Design for All'. As a designer, problem solver, advocate or individual, you may have many years under belt or may be new to this field. Therefore, the contents of this newsletter may be nostalgic, informative or motivational for you. Whichever they are, I hope you will be touched, reenergized, and feel supported and linked to history.

This edition of the 'Design for All' newsletter has been created in a time of economic challenges for many countries accustomed to affluence. The experience of repeated budget cuts and layoffs has been humbling for many – resulting in carefully made choices. These choices expose core values when the extras are stripped away. My university has had to make similar choices, cutting deep, reflecting its priorities. One priority that has not fallen away is the support of research, development and education in Universal Design. The mechanism through which the work is supported shifts and grows – it is supported by our Dean, researchers, students, faculty, and constituents. Like Ron's definition of Universal Design, The Center for Universal Design, at NC State University, is "unobtrusively" and sometimes "invisibly" supported, growing to the extent possible benefiting people of all ages and abilities. I believe that Ron Mace would be pleased to see the support of Universal Design within the College of Design at North Carolina State University.

We therefore pay tribute to Ron Mace by reflecting on his life, his professional contributions, the promulgation of universal design, and his legacy extended through the continued work at the Center for Universal Design and NC State University. Though I joined the Center for Universal Design after Ron passed away, I –like so many– am grateful for and indebted to his work and vision.

Kind regards,

Sharon Joines, PhD

Center for Universal Design
Research in Ergonomics and Design Laboratory, Director
Assistant Professor of Industrial Design
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CHAPTER 1

TRIBUTE TO RONALD L. MACE

RONALD L. MACE, 1941-1998

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Ronald Mace passed away in his home in Raleigh, NC, on June 29, 1998. The cause was heart arrhythmia resulting from polio, he was 58. Mr. Mace's wife, Lockhart Follin-Mace, preceded him in death in 1991. He was survived by his companion, Joy Weeber of Raleigh.

Ron has been described as a visionary, an advocate, a consummate champion for accessible and universal design, and an educator who worked tirelessly and was confident in his convictions. But to those who worked closest to him and knew Ron best, they reflect on his humor, smile, humanity, and humility.

The Ron Mace Memorial Fund was been established to help support design students carry out Mace's life work. Renewed efforts are being made to make the last push of the Memorial Fund in order to reach the endowment level which will afford the support of a student studying Universal Design each year. Tax deductible contributions may be made to the Ron Mace Memorial Fund in care of the NC State University College of Design.

Formative Years

Ronald Lawrence Mace was born in Jersey City, New Jersey in 1941 and spent his first five years like many little boys playing in the north eastern portion of the United States. In 1946, his father moved the family south. Ron grew up in a mid-sized southern town of Winston-Salem, North Carolina. Life in southern towns in the late 1940's was generally slow paced and marked by planning for growth. For example, in 1946 the alderman of Winston-Salem adopted a resolution supporting the proposal to move Wake Forest College to Winston Salem from its home in Wake Forest North Carolina outside Raleigh. To support the areas growth water supplies were enlarged, aerial maps were made of the city, an east-west expressway was approved, and roads were paved. Ron built soapbox derby carts with his dad and entered model airplane competitions with his older brother. "He had an innate ability to make things. He was always an inventor and builder," recalls Joy Weeber, a disability advocate and the life partner with whom Ron shared his last four years¹. But amid the progress in the States and the wars abroad, the polio virus swept across country. In 1948, a severe polio epidemic hit North Carolina. Though North Carolina was one of the first states in the US to require polio vaccinations for children -- many had already contracted the disease and lives were altered forever.

At the age of nine, in 1950, Ron contracted polio. After spending a year in the hospital, Ron left the hospital using a wheelchair. Rather than institutionalizing their son, Ron's parents brought him back home, back to his community and back to school. His parents brought him home to a life with limited modification and no external support. The schools and community of Winston-Salem were not well prepared to meet the needs of individuals surviving polio, partially paralyzed, and using a wheelchair for mobility. For Ron and his family this meant, Ron was carried up and down the stairs of the schools he would attend – elementary school, high school and eventually college. Ron's wheelchair could not fit through bathroom doors. His solution was to confront his

¹ From Access to Design Professionals http://adaptiveenvironments.org/adp/profiles/1_mace.php

barriers and built what he needed to accomplish tasks we take for granted. In addition to building a custom bed, Ron designed and welded a narrow, rolling stool to afford him access to the narrow doors to the bathroom.

Though admission to the College of Design is at best tough, Ron was discouraged from applying to the architecture program at NC State University. The Dean of the school at that time was reported as having said that the rigors of the program would be too demanding. Ron wrote about that experience in a paper presented at the National Forum on Careers in the Arts in June 1998. "When I applied to architecture school, I was told by the dean not to try. He felt that a person with a disability could not make it through the program, and did not have any business trying. He reasoned that I could never do the work successfully nor find and maintain a job. I have no idea what experience he had with anyone else with or without a disability upon which to base such strong opinions. I completed school as a result of the tenacity of my family. They devoted a large portion of their lives for the six years I was in school to ensure that I was carried whenever necessary through an inaccessible, and even hostile, environment. There was neither assistance nor accommodation made. It was difficult, but not impossible to successfully complete the program. I entered my field before physical and programmatic access were required and discrimination prohibited, before any assistance or advanced technology could be of help. This situation has radically improved." In 1966, Mace graduated with a B.A. in Architecture from North Carolina State University's School of Design.

Effort & Impact

After four years of practicing conventional architecture, Ron became involved in an effort to produce the first national building code for accessibility.

In 1973 Ron assisted in the passage of an amendment to the North Carolina Building Code for handicap access. The introduction of the handicap section was essential in establishing people with disabilities as a community deserving of recognition in civil rights legislation. The same year, the Federal Rehabilitation Act was implemented, prohibiting discrimination against people with disabilities in regards to employment by federal departments and organizations receiving federal funds.

For the next two decades Ron provided design consulting services as president of Barrier Free Environments, Inc (BFE). While at BFE, Ron also produced a number of publications on accessible design including *The Planner's Guide to Barrier Free Meetings* (1980), *The Accessible Housing Design File* (1991), *The Americans with Disabilities Act Accessibility Guidelines Tech Sheet Series* (1994-95), and *Highlights of the Americans with Disabilities Act Standards for Accessible Design Slide Show* (1993).

In 1988 Ron assisted in the development of the Fair Housing Amendment Act, barring

discrimination in the sales or rental of housing on the basis of disability, and requiring new multi-family housing to meet new adaptability & accessibility requirements.

After working as an architect, designer, advocate, author and visionary, Ronald L. Mace returned to NC State University and the College of Design in the late 1980's. When he left the college in 1966 he was an eager intern supported by an amazing family. When he returned, he was a nationally and internationally recognized architect, product designer, and educator. He had made his mark on the nation by championing the disability rights movement. Accessibility was now etched in history with the strength of the law behind the Americans with Disabilities Act (ADA). But for Ron access was not enough. He coined the term "universal design" to describe the concept of designing products and the built environment to serve the needs of people regardless of their age, ability, or status in life.

In 1989 Ron established the federally-funded Center for Accessible Housing, currently known as The Center for Universal Design (CUD), at the School of Design at North Carolina State University in Raleigh. The focus of the center was to engage designers in conversation through Universal Design as both policy and philosophy. Mace and the staff remained involved in legislation after joining the school, helping shape the Americans with Disabilities Act (1990), a milestone in legislation aimed at preventing discrimination in employment practices and spaces of public accommodation.

During the early 1990s Ron focused on addressing architectural barriers in regards to the ADA, ANSI and ISO Standards through a series of presentations and lectures. While this provided designers with an understanding of code in regards to usability, it failed to convey the idea of Universal Design, as code provides designers with minimum requirements, not ideal conditions. From 1994 and 1997 the CUD took on the task of developing a set of guidelines that could provide designers with a conceptual understanding of Universal Design, and in 1995 organized a collaborative brainstorm with designers from around the nation. Over the course of two days the group developed what was to be the Principles of Universal Design.

On June 19, 1998, Ron Mace delivered what would be his final speech at "Designing for the 21st Century: An International Conference on Universal Design," hosted by Hofstra University. The conference was the first international conference on universal design, a topic that was dear to his heart and the focus of his life's work for 28 years. More than 450 people from 19 countries were in attendance and were testament to his inspiration of a growing international movement. Ron explained, "Universal design seeks to encourage attractive, marketable products that are more usable by everyone. It is design for the built environment and consumer products for a very broad definition of user."

Last Speech

In his final speech, Ron addressed what is perhaps the most confusing issue surrounding universal design. Specifically, he helped illuminate the distinctions between universal design and the associated concepts of barrier-free design and assistive technology. It is important, indeed, to clearly define these concepts as they are so closely linked to each other, and now, over a decade later, to a lexicon that has broadened itself even further.

Let's look, as Ron did, at barrier-free design. Barrier-free design, embodied in ADA and other legal measures, are mandates that dictate the tectonics of accessibility. They dictate how far from the floor a switch can be, how much space is needed around a toilet, where the handles should be for a shower, and a myriad of other building dimensions. These guidelines, however, are just that—guidelines. They are not a design philosophy, they are not a mode of thought, and they are not a goal in and of themselves. They are, however, driven by the goal of providing access for people requiring wheelchairs for mobility, and it is this goal behind the mandates that links them to universal design.

Mandates like the ADA are considered by many to be a step in the right direction, and they play an important role: they provide the “what” and “where” for a designer. Where they fall short is the more important issue of “why”. Why should a countertop be at a given height? Why should a light switch be placed in a certain way? Why can't we design for the average person? The answer lies in the very term “average person”. The term itself suggests a mathematical mean of data, not a real, walking, breathing human being, and in fact, a great number of able-bodied people do not resemble the “average person”. Instead, universal design as a philosophy suggests that products and spaces should be designed in such a way that they are usable by the greatest number of people possible, with little or no difference in the manner in which they are experienced.

This is a lofty goal, and Ron fully acknowledges this in his speech saying “I'm not sure it's possible to create anything that's universally usable. It's not that there's a weakness in the term. We use that term because it's the most descriptive of what the goal is, something people can live with and afford.” Today, this idea is embodied in a family of terms including “universal design”, “inclusive design”, and “design for all”, all of which share the same goal: design for the broadest possible user group.

The term “universal design” itself has major implications. Design--as an act, a thought process, and a profession--requires the conceptualization of a solution for a given situation. The fact that UD is a design approach inherently makes it a proactive measure. Adaptive technologies, on the other hand, are reactive measures that, whether intentionally or not, tend to reinforce the notion of an “average” ability. Ron's eyeglass example is perhaps the best to illustrate this notion. Eyeglasses are designed

and used to correct disabilities of visual acuity, the overall goal of which is typically 20/20 vision. This goal, though, is itself reinforcing the notion of an average ability, given that we measure vision by what the “average person” can see at a distance of twenty feet.

According to Ron’s perspective, assistive devices were not and are not consumer products. They are instead personal-use, or more accurately, patient-use devices designed and built without any consideration of “whether... the product looks nice, is easy to live with, or is available at a marketable price...” Thankfully, this is one area where there is evidence of change. Take, for example, the blood glucose meter, a device used multiple times daily by diabetics and others with blood sugar disorders. While it was once a bulky piece of equipment that was hard to use and even harder to understand, there are now a variety of portable, handheld designs that are easy to carry, easy to use, and easy to understand. Thanks to advances in technology and a greater focus on the user-product interaction, the meter has begun the shift from being simply an assistive technology to a true consumer product. In his final speech, Ron also recognizes that these shifts can occur in both directions. That is, consumer products can shift their target audience and become more universally designed products.

As Ron noted, “sometimes we find universal design just seems to happen.” More often, though, we find that universal design just doesn’t seem to happen. As the need for universal design continues to grow, it is important to continue expanding our understanding of its potential. To that end, it is as important now as it was a decade ago “for all of us—designers, educators, researchers, advocates—to really understand this relationship between barrier-free, universal, and assistive technology in order to develop and implement truly universally usable designs.”

“As one of the team fortunate to work with Ron Mace in developing the 7 Principles of Universal Design, I appreciate your tribute to him in Design for All. I consider it a mark of his greatness that, as much as his leadership and skill, I remember his humor and humanity. His memory would be the less without these.”

- Jim Mueller

CHAPTER 2

2.1 STUDENT WORK

A collection of student explorations, including studio projects and independent studies, focusing on issues of usability in product design. Each project focuses heavily on ergonomics and human factors as outlined in the Principles for Universal Design, as both a tool for product evaluation and design development. In each report students examine contemporary product markets, identify criteria for evaluation and accordingly develop prototypes. All work was carried out at the by students (Undergraduate & Graduate level) of the Department of Industrial Design, College of Design, North Carolina State University, Raleigh.

2.1.1 WAIT STAFF TRAY

PRODUCT REDESIGN OF WAIT STAFF TRAY: CONSIDERING MUSCULAR EFFORT, POSTURE, AND UNIVERSAL DESIGN

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Problem Statement

The problem identified was strain and injury incurred by restaurant wait staff that was attributed to serving food. Several studies have already been conducted addressing the issue of postures and injuries in wait staff. No study goes on to create methods or products that would help alleviate awkward postures and injuries. Several sources list the restaurant industry as one of the largest and fastest growing industries in the nation. In addition to that, the aging population of the workforce creates a real need for a solution to this problem (see Figure 1).

3 Activities that often put restaurant wait staff in awkward postures



Pick up

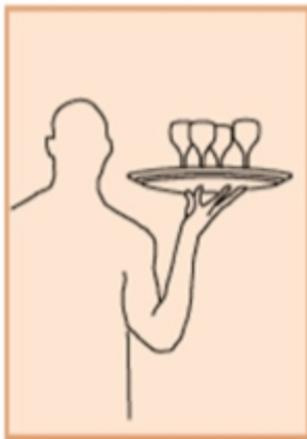


Transport

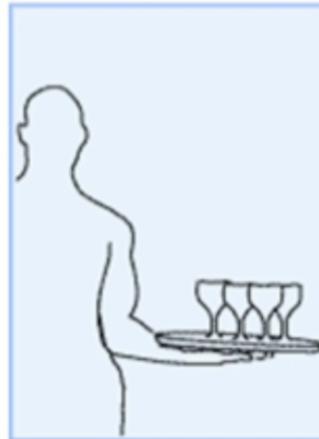


Delivery

According to the U.S. Department of Labor, wait staff should carry plates with their elbows close into their body to lessen the strain on their arms and back. Avoid bending at the wrist or extending upward at the fingers. Their shoulders, arms, and hands should be in a neutral position rather than bent.



Unsupported Elbow and Finger Posture



Better Carrying Posture

Pictures courtesy of the U.S. Department of Labor

Figure 1: Restaurant Wait Staff

Goal

The design goal is to create a device that will aid in the delivery of food to customers and encourage wait staff to be in neutral body positions while carrying out their duties. Specific goals include eliminating, as much as possible, fatigue and discomfort in the backs, shoulders, and wrists of wait staff.

Background

Over 2 million people are listed as working in the 'Waiter and Waitress' category of the Bureau of Labor and Statistics. The Liberty Mutual Research Institute for Safety funded a study conducted by Patrick Dempsey which reported 42 percent of these people reported musculoskeletal injuries. Of these, 11 percent reported injuries to the shoulder and listed lifting heavier trays as a cause for concern.

Research

There are very few studies that concentrate on the physical tasks associated with food serving. Filiaggi and Courtney's "Restaurant Hazards" analyzes the types of injuries that typically occur in the restaurant industry. The major studies found that discuss wait staff injuries related to serving food are Dempsey's "Cross-sectional investigation of task demands and musculoskeletal discomfort among restaurant wait staff" and Jones, Strickfaden, and Kumar's "Physical demands analysis of occupation tasks in neighborhood pubs." These studies document ergonomic problems in common wait staff practices. Dempsey's identification of specific musculoskeletal discomfort and the average weights was thorough. Currently, there is little information on the relative merits of different approaches to serving food, such as using trays vs. carrying individual plates, the weights of plates and trays handled and other parameters of the materials handling demands that that would help inform sound ergonomic recommendations" (Dempsey 95). Jones, Strickfaden and Kumar's study enumerated specific torques and strains on muscles and ligaments, demonstrating further evidence of the problem.

In addition to statistics provided by government agencies, information regarding the economic expenses of workplace injury were found in Jeffery N. Katz's "Lumbar disc disorders and low-back pain: socioeconomic factors and consequences" According to this study low-back pain cost in the United States exceed 100 billion dollars per year and two-thirds of those costs are due to lost wages and reduced productivity. The US Department of Labor recommends carrying a tray with elbows close to the body to lessen strain on arms and back. The Department of Labor states that injuries can occur when assuming awkward postures while serving food, particularly while lifting heavy trays with too many plates on them, or balancing or lifting heavy trays above shoulder level (see Figure 2).



Ergonomics and Food Servers

HS05-037B (9-07) A 5-Minute Safety Training Aid

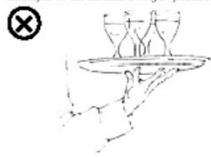
To reduce the risk of injury, servers should practice safety tips while on the job.

- Carry a loaded tray with your shoulder, arm, and hand in a neutral position as shown below.
- Carry a tray as close to your body as possible.
- Balance the tray on both your arm and hand.
- When it's not possible to carry a tray in this manner, alternate which hand you use to carry the tray and vary your posture.
- Balance the load and place heavy items close to the center.
- Make sure the tray is clean and dry.
- Carry fewer plates and other items at a time. Make two trips or ask other servers to help carry large orders.
- Carry plates, coffee pots, and water jugs close to your body.
- When pouring, move the glass or cup as close to you as possible, rather than overreaching with a full jug.

Example of awkward wrist and elbow posture



Example of an awkward finger posture



Courtesy of Workers' Compensation Board of British Columbia

Example of preferred posture



The Texas Department of Insurance,
Division of Workers' Compensation (TDI, DWC)
E-mail resourcecenter@tdi.state.tx.us
or call 1-800-687-7080 for more information.

Safety Violations Hotline
1-800-452-9595
safetyhotline@tdi.state.tx.us

Figure 2: Recommended Postures While Serving Food

Market Research

A market survey and patent review using internet search engines and the varying combinations of these keywords: ergonomic, serving tray, stackable, one-handed, restaurant, compact, comfortable, and serving device. We found nine patents dealing with serving trays and food service. Most of the trays found are designed for carrying only drinks or light loads of hors 'douvres (see Figure 3). Although some of the trays incorporate one or two 'ergonomic' features, the team found no trays that were designed with a comprehensive ergonomic approach in mind.



Figure 3: Market Review

Design Development

In order to contribute productive solutions to the fatigue and injury problems, the team first needed to thoroughly understand the environments in which the servers work and the correlations between certain work behaviors and the corresponding reports of physical pain and fatigue. Observations were conducted in five local restaurants. All the restaurants were mid-range (\$8-\$15 per meal), full-service restaurants. These host sites included sites where wait staff members handled food using trays and sites in which wait staff members directly handled food plates without trays.

The design team collected the following data for each participating server: the number of years experience serving, height, weight range, age, the number of people served per night, the average lengths of shifts, if he or she was instructed how to deliver food, how he or she chose to deliver food and why, how many plates of food he or she was comfortable carrying at one time, whether he or she had any difficulty transporting food and drink, whether he or she had physical discomfort attributed to restaurant work or made worse by restaurant work, how long discomfort is felt after work ends, whether any brace or assistive device is used to aid in food service, and what suggestions he or she could offer for improving the tasks. Additionally, each server was asked to fill out a diagram of the body using a modified Borg pain scale.

At all sites, each selected wait staff member was observed while performing the tasks of pick up, transport, and delivery of food. The goal was to capture the full cycle of pick-up, transport, and delivery at least three times for each participant.

After analyzing data from field study, the recommendations for the design was to develop a new tray to relieve loading on the back (see Figure 4). Reductions in load will be sought by keeping the load close to the wait staff's center of gravity. The tray should be designed to carry the load at the waist for two reasons: 1) to avoid unnecessary lifting of the load to the shoulder when the load is picked up and delivered at waist level and 2) most wait staff carries the load on their arms at waist level which may improve the likelihood of adoption of the new tray.

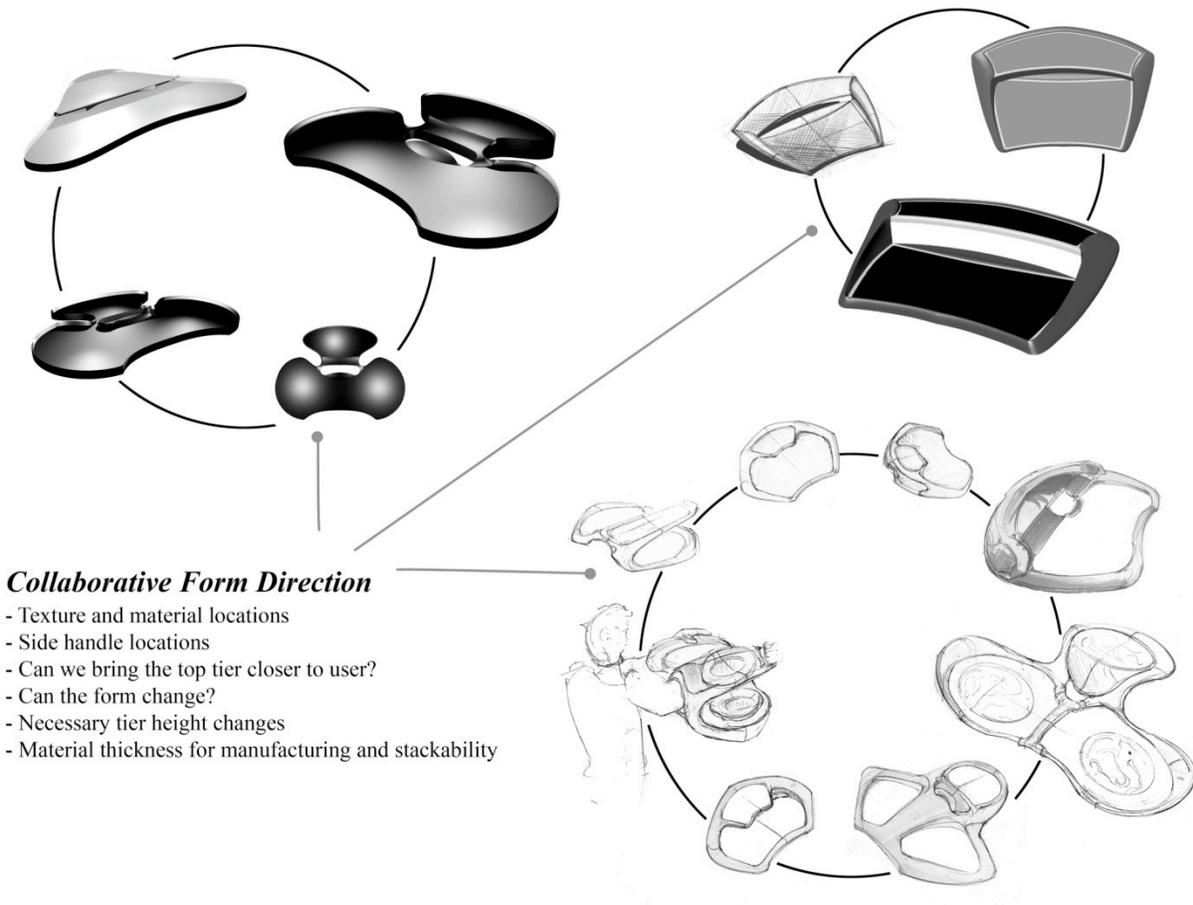


Figure 4: Design Development

The designs generated through ideation were evaluated based on the following criteria

- 1) appeal to restaurants with a high customer turnover leading to a fast paced serving environment;
- 2) promote neutral posture of wait staff during use;
- 3) use of tray should be easy and efficient (requiring no additional time to deliver meals);
- 4) promote meal carrying at waist level;
- 5) encourage the server to keep the load as close to their body as possible;
- 6) afford load delivery of 3-4 plates; and

7) remain stackable and washable

The new tray design is simple and sleek making it ideal for use in many restaurants (see Figure 5). It will fit in with almost any décor without sticking out. The simplicity of the design will allow restaurants to use the tray for many years without the look becoming dated.

Final | Tray Design

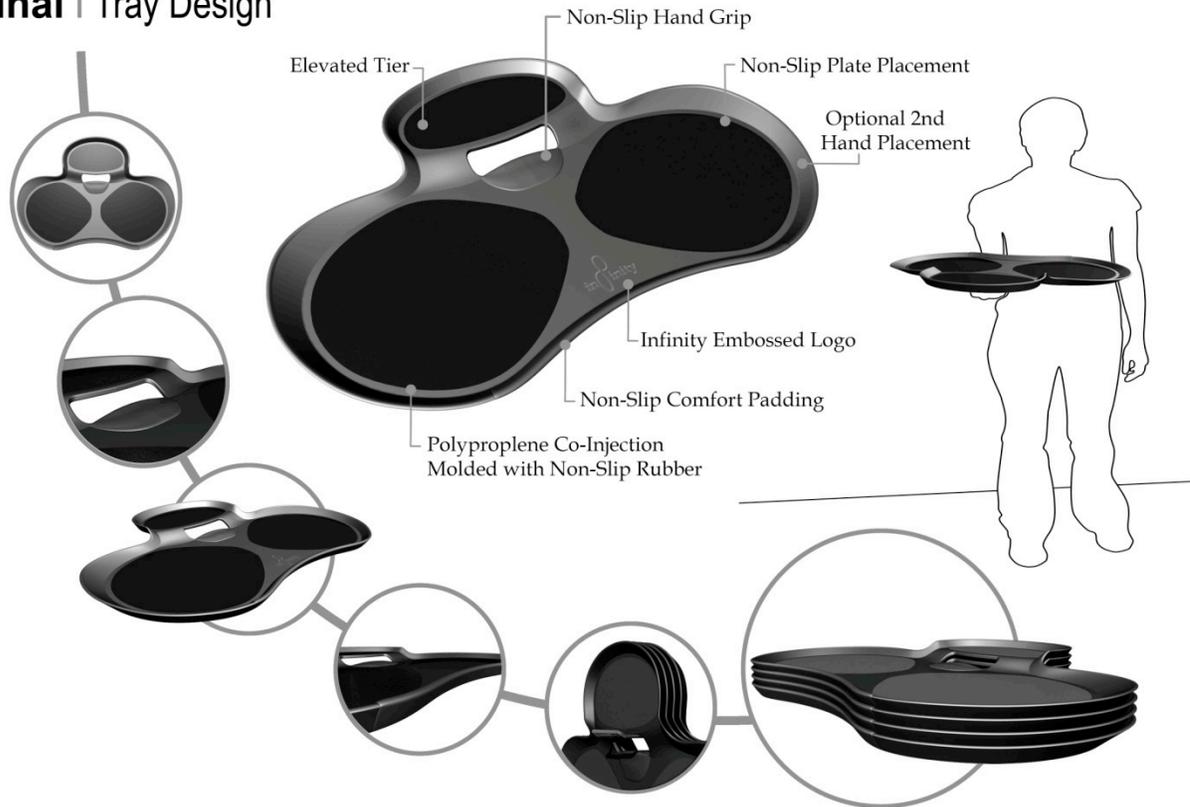


Figure 5: Infinity – New Tray Specs

UD Assessment

"Universal design seeks to encourage attractive, marketable products that are more usable by everyone. It is design for the built environment and consumer products for a very broad definition of user."

- Ron Mace

Criteria in developing a new tray for restaurant use, the principles of universal design were taken into consideration when designing this product. The design lent itself to guidance from four of the principles (see Table 1): equitable use, flexibility in use, simple and intuitive to use, and low physical effort. The remaining three principals were considered in the design phase but play a lesser role in the design development owing to the type of product. Future designs will explore alternatives which will push the principle of Universal Design further in meal delivery (which is beyond the scope of this student design project). Meeting the needs and expectations of the owners while delivering meals from existing kitchens and through the existing layouts of operating restaurant dining room facilities was a definitive challenge.

Table 1: Applications of Universal Design Principles

Method	Equitable Use	Flexibility in Use	Simple & Intuitive	Low Physical effort
Old Tray at Shoulder	Low	Low	Moderate	Low
Old Tray at Waist	Low	Moderate	Moderate	Low
Arm Carry	Low	Low	Low	Low
New Tray	Moderate	Moderate	Moderate	High

Performance of Design for a principle:

- NA- not applicable to this assessment,
- Low – poor performance,
- Moderate – moderate performance,
- High – Strong performance

Discussion of application of Universal Design

The new tray design was benchmarked against the three current methods for meal delivery. Each method’s performance was rated as low, moderate, or high for each of the principle of universal design (see Table 1 above). The arm carrying method was rated low against each of the principles. The old tray situated at the shoulder level was also rated low against the principles except for a moderate rating for simple and

intuitive. The old tray situated at the waist level was rated low for equitable use and physical effort and moderate flexibility in use and simple and intuitive categories. The new tray design was rated moderate against the principles with a high rating for low physical effort. Though the new tray was an improvement when considering the principles of Universal Design, the task of meal delivery has great room for improvement so that meal delivery is more usable by everyone. This design is more attractive and broadens the user group for the meal delivery tray.

Equitable Use

The restaurant is a large industry and employees many people to operate and manage daily restaurant task. Wait staff in these restaurant have employees with diverse abilities. The new tray was designed to be an attractive, easy to use tray to help reduce injuries and make waiting table task easier. One consideration was the load stability and potential for accidents if the employee were to tip the load due to personal instability, tremors or unexpected changes in directions (e.g. patrons moving about in the dining area).

Flexibility in Use

The design team created a tray design that could be effectively used by a wide variety of body sizes and types. The width of the new tray's grip hole is 19.69mm (5.0 inches). According to PeopleSize Anthropometry software, this grip width of 19.69 inches accommodates the 99th percentile US male. The depth of the new tray's handle opening is 3.8mm (1.5 inches), which also accommodates the hand depth at middle finger knuckle for the 99th percentile US male. In addition, the design accommodates right or left handed access and use

At the narrowest point of the tray, the distance from the elbow crease contact surface and the beginning edge of the grip opening is 262.1mm (10.32 inches). Because the 1st percentile female has an elbow-wrist length of 229mm (9.01 inches) the distance between the proximal tray edge and the grip will accommodate practically all adults.

The positioning of the tray in a bent elbow posture reduces muscular loading and minimizes awkward postures in the elbow, shoulder and wrist. This allows individuals with less strength and range of motion to successfully use the new tray.

Simple and Intuitive Use

In a restaurant setting, efficient is an important value to ensure quick and fast service. The new tray was design for wait staff to load, carry, and deliver without crowding of plates on tray, to distribute weight efficient, and give user adequate placement of hands to support load. The shape and placement of materials on new tray was designed to give indicators of placement on the contours of the body and hand placement to eliminate unnecessary complexity.

Low Physical Effort

Our main goal in this design was to accommodate users with a design that could be used efficiently and comfortably with a minimum of fatigue and accidents. Providing design requiring low physical effort was a crucial universal design principle that was needed in order to change existing restaurant methods. The final tray design features a large area that will hold two large plates and a tier farther from the body that will support one large plate. The advantage of the tier is that a plate can be cantilevered partially over plates on the lower tier. It also allows clearance for the hand to come through the hand grip near the middle of the tray. The flared edges at the side of the lower tier adds versatility to the tray by allowing the user to use two hands and hold the tray close to the body. The new tray puts the user in the ergonomically recommended position and decreases muscle activity by encouraging the user to keep the load close to the body.



Figure 6: Infinity – New Restaurant Tray

Acknowledgements

The authors acknowledge Michael Rall, Rachael Wilson and Janelle Moore as team members in the studio which produced the original design project.

The authors acknowledge Bong-il Jin for his styling instruction, reviews, critiques and recommendations. Without his knowledge and guidance, the final models would lack the style and refinement that designers leverage to turn an idea into an object worthy of mass production.

Special thanks are extended to the restaurants and participating staff members which allowed us to collect our initial data and to test our working prototypes.

The studio during which this project was conducted made use of the RED Lab in the College of Design. The RED Lab is partially supported by the Center for Universal Design, the Ergonomics Center of North Carolina and UserView Inc.

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2.1.2 GROCERY BASKET

PRODUCT REDESIGN OF GROCERY BASKET: CONSIDERING MUSCULAR EFFORT, PRESSURE DISTRIBUTION, AND USER ACCEPTANCE

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OVERVIEW

At the beginning of the project, it was noted that there are a number of ergonomic issues with existing hand-held shopping baskets. The basket handles are uncomfortable, awkward, and difficult to pick up with one hand. The baskets do not distribute the load effectively, and the shell of the basket is uncomfortable against the body. The hand-held shopping basket (henceforth referred to as “basket”) is an interesting object of study because there are few basket designs that address ergonomics.

There were a couple of specific areas of focus during the redesign of the basket. First, there was a need to address the load distribution. Current baskets are box-shaped. This shape did not appear to lend itself to carrying loads efficiently. It was thought that altering the shape of the shell of the basket could improve the load distribution. Second, the handles on existing baskets are uncomfortable for both gripping and draping the basket over one’s forearm. The handles are made of a thinly molded plastic or metal which, when used in their upright positions, frequently pinch the skin. The handle is an important feature of the basket because it is the body-to-basket contact area that bears the load of the entire basket. Lastly, the current baskets’ appearances are unappealing. Many of these baskets have a square and boxy shape. The sides and base are perforated in a grid-like pattern of squares.

A market and patent review revealed few patents on hand-held shopping baskets. Some of these address the basket’s shape and some address the connection orientation of the handle.

For this study we addressed several problems associated with the hand-held shopping basket. To study the basket in a shopping setting where baskets were used more frequently than shopping carts, we picked small to mid-range grocery stores that sold specialty products such as organic and natural foods. These stores also had a friendly community setting, which provided greater dialogue when collecting our observation data. Our goal was to observe how customers interacted with their baskets, including how they carried them, what they used them for, why they used them, and what kinds of problems they experienced while using the basket.

PHASE I: MARKET AND LITERATURE REVIEW

During the literature review, the following indices were searched: Google Scholar, Design Applied Arts Index, and Engineering Ergonomic Abstracts. The following keywords were used during these searches: shopping basket, grocery basket, supermarket basket, ergonomic basket, load-carrying, hand basket, ergonomic carrying handle, child carrier, infant seat, hand-held shopping basket, asymmetric loading. The literature review resulted in a limited amount of literature related to the hand-held shopping basket. “Hip joint forces during load carrying” by Bergmann, Graichen, Rolmann, and Linke, provided some insight as to how various load-carrying affects the hip. An article by Desai and Talukdar, “Relationship between Product Groups’ Price Perceptions, Shopper’s Basket Size, and Grocery Store’s Overall Store Price Image”, provided information on baskets’ capacities. Two articles relating to infant carriers were helpful in considering how to make a heavy load easier to carry. These articles were “Ergonomic Contribution to the Development of a Baby Carrier”, by Bonapace, Borghi, Mancuso, and Menarini; and “This Infant Carrier Is Too Heavy; An Ergonomic Redesign of Infant Carriers”, by Roca.

For the patent research, the following patent websites were searched: United States Patent and Trademark Office, and Free Patents Online. The same keywords were used to search these websites (shopping basket, grocery basket, supermarket basket, ergonomic basket, load-carrying, hand basket, ergonomic carrying handle, child carrier, infant seat, hand-held shopping basket, asymmetric loading). The results showed that ergonomic baskets were currently on the market. A total of three baskets were found with ergonomic contour exteriors. The Target brand has a patent on a basket in the form of a peanut shape (Figure 1). This shape is designed to contour the natural shape of the hip. This same basket has a handle that runs from end to end across the length of the basket. Results also showed patents of different handle connection orientations.

This included handle orientations that are seen most commonly in grocery stores (two handles that fold up to join as one) (Figure 2). Results also showed basket accessories such as basket holders (Figure 3).

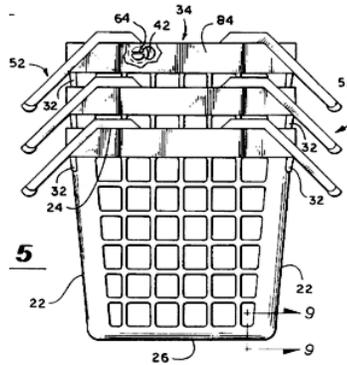


Figure 1



Figure 2

Figure 3

PHASE II: SOLUTION DEVELOPMENT

Considerations. Initial concepts the team explored included the addition of wheels, a belt to secure groceries and similarly a shoulder strap. Weight distribution and comfort were essential design factors. Limiting factors included consideration of use in spaces and materials for design.

Accordingly, the use of flexible materials became topic of discussion. Although a flexible mesh would provide ease of use and reduced weight, the stress applied to basket contents becomes a point of concern. Making part of the basket flexible and other parts structured was considered. Ultimately, how the basket meets the user was determined to be the most effective means of improving weight distribution and comfort.

Handle exploration. The first concept was an idea of creating two half-handles that would meet together in the middle of the basket and form one (Figures 4 & 5). Each handle would have a magnet attached, enabling the handles to become one when pulled together. The two handles would be set on soft mesh material. This concept would eliminate any pinching that is commonly associated with handles currently on the market. The problem with this concept is that adding more material pieces to the basket would make them susceptible to breaking or needing to be replaced.



Figure 4



Figure 5

The use of flexible or rigid materials for the handle became a point of debate, bringing up issues of form-fitting and positioning, but issues of manufacturing (the entire basket out of one material) and overall durability became of greater concern and consequently the flexible handle concept was discarded.

Another point of concern was connection between handle and basket. Current baskets have four connections, two per handle. Using one handle, only two connection points are needed. This solves the issue of the two-handle pinch, but as result load balance becomes an issue.

Final handle concept. The handle's final design reflected its simple and intuitive use. The handle was positioned slightly further down the exterior of the basket, which results in a shorter distance between the handle and the top rim of the basket. Because the basket has only two connection points, a locking mechanism was designed for when the basket is activated and in use. This occurs when the customer pulls up on the handle. Small dimples along the side of the basket lock the handle in place while the pivot wheel locks in the same way. To account for the inner curve of the basket, the handle is somewhat flexible, otherwise the handle would have provided difficulty when pivoting to either end. The center pivot area has approximately a quarter-inch give. The rotation revolves on a plane that is parallel with the bottom of the basket. To accommodate for forearm holding, the handle has a slight curve on the inside edge of the basket. The center of the handle becomes slightly thicker to allow for a more comfortable handgrip.

PHASE IV: SOLUTION STYLING AND FINAL DESIGN

The team decided to research the marketplace of the target stores for which they were designing. The grocery stores were mid-range in size. They sold specialty food items that offered organic and natural foods. Most of these stores had a small community feeling and were involved in promoting a healthy environment and a healthy lifestyle. Most of the customers reflected this way of living and since a “green” lifestyle is now dominating popular culture, the team decided to put an “eco-chic” stylized direction into the basket.

The final design of the basket encompassed the styling direction of using a tree that is embossed on the inside and outside edge of the basket. There is a center trunk up the middle and two branches that sprout out from either side. The handle connects and pivots on the middle of the tree trunk. Outside of the tree and the branches are perforated honeycomb shapes throughout the front, back, sides and bottom. The basket’s color is a greenish lime color, which represents the eco-chic styling direction.

The new basket design is stylistically better than what is available on the market because baskets currently on the market lack aesthetics. The reason the team decided to use a tree for the basket’s surface design is that it creates the sense of growth and a natural setting. This branding connects well with the grocery markets we designed for. It will assist in creating an image for the store in which the store is of higher quality and cares for their customers.

PHASE V: SOLUTION EVALUATION

LAB ASSESSMENT: TEKSCAN

Variables. Using a Tekscan, the new basket prototype was also tested against an existing basket to compare pressure distribution. Data was collected on four participants, three male and one female. Four conditions were tested to determine product contact area, including: old basket/hand hold; new basket/hand hole; old basket/forearm hold; new basket/forearm hold. The peak contact pressure was also recorded for each of these four conditions. Baskets were tested with a symmetrical load of ten pounds.

Findings. The contact area for the hand-to-handle posture was 15% greater on the new basket. The contact area for the forearm-to-handle posture was also 15% greater on the new basket. The new basket better distributes the contact area across the points of interface (Figure 8).

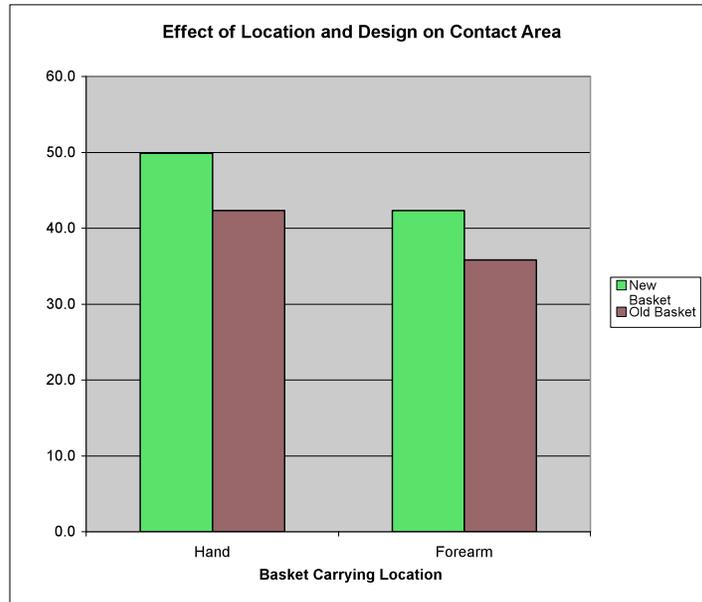


Figure 8: Effect of Location and Design on Contact Area

The new basket’s peak contact pressure for the hand-to-handle interface was greatly reduced. Its peak pressure was 26% lower than the old basket. The new basket’s peak contact pressure for the forearm-to-handle interface was also greatly reduced. Its peak pressure was 43% lower than the old basket. These findings indicate that the new basket is much gentler on both the hand carry and the forearm carry (Figure 9).

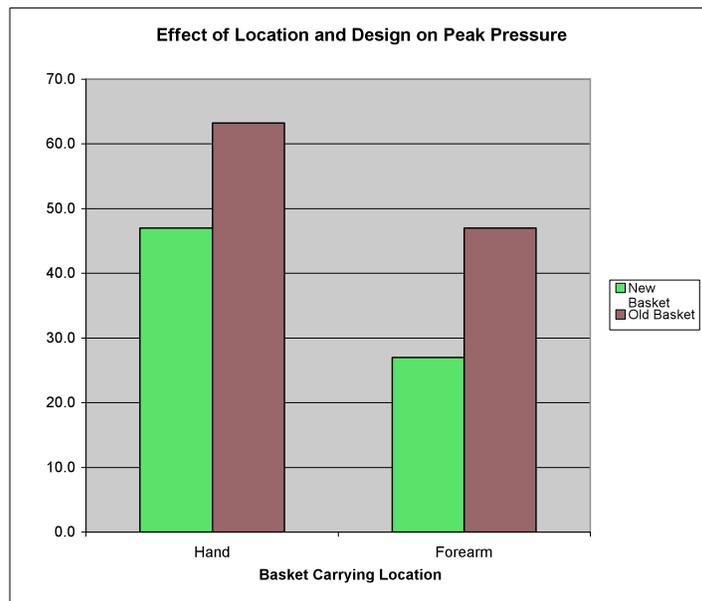


Figure 9: Effect of Location and Design on Peak Pressure

FIELD TESTING

Variables. Of these participants, four were female and one was male. Participants were asked to shop for a prescribed list of groceries, which included a loaf of bread, box of cereal, can of beans, and peanut butter. Participants were instructed to shop for the items, first with the old basket, then with the new prototyped basket. After completing their two shopping trips, they were asked to rate on a scale of 1 (strongly disagree) to 5 (strongly agree) the following questions:

- 1) The old basket handle is comfortable;
- 2) The old basket handle distributes the weight well;
- 3) The new basket handle is comfortable;
- 4) The new basket handle distributes the weight well;
- 5) The curve in the new basket was helpful/comfortable.

Participants were also asked the following:

- 6) If you were holding it in your hand, which handle would you prefer overall?;

- 7) If you were holding it draped over your arm, which handle would you prefer?

Additional comments were also recorded.

Findings. The average score for question 1 was 2.2, question 2 was 1.8. 3 was 3.4 and question 4 had an average score of 3.6. The average score for question 5 was 3.8 (Figure 10). These scores show that, overall, the new basket was preferred to the old basket.

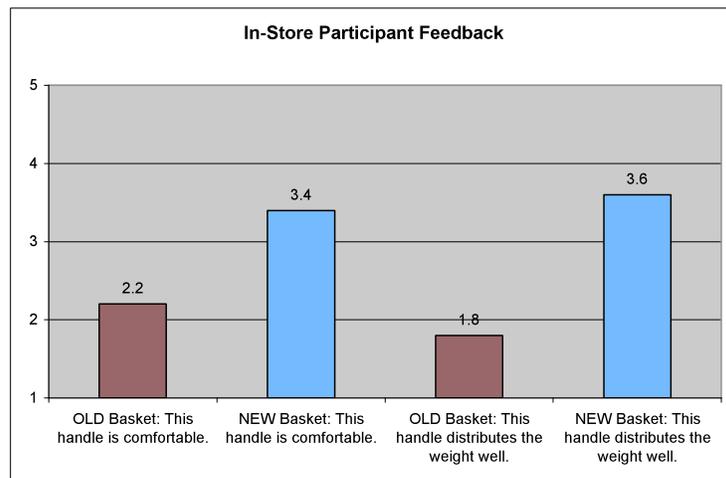


Figure 10: In-Store Participant Feedback

UD ASSESSMENT

In evaluating baskets on the market and of student design, the Principles of Universal Design provide an effective means of determining the overall usability of a product (Figure 11). In regards to design decisions, the primary focus was equitable use – is this product usable to people of varying abilities? In regards to flexibility of use, a single handle, comfortable enough to drape over the forearm throughout the shopping experience affords an individual with one hand to easily use the basket. Increasing contact area between the arm and basket provides greater load distribution, reducing physical effort. In addition, having one handle, as opposed to two, reduces chances of pinching, and accordingly user error.

Principle	Current on Market	Student design
Equitable Use	Low	High
Flexibility of Use	Low	Moderate
Simple & Intuitive Use	High	High
Perceptible Information	NA	NA
Tolerance for Error	Low	High
Low Physical Effort	Low	Moderate
Size and Space for Approach & Use	NA	NA

Figure 11 UD Assessment of Existing vs Student Basket Design

CONCLUSIONS AND RECOMMENDATIONS

Lab testing found that the new basket design did not move the load closer to the body. However, the new design will hopefully change the way people behave with the basket. Interface testing showed that the new basket handle is gentler than existing designs on both the hand and the forearm. Although the lab testing showed that the new basket did not bring the load closer to the body, it was perceived as being effective in this area during field-testing. Issues of stacking were also evident.

Overall, the feedback on the new basket design was positive. In field-testing, it exceeded in performance in all areas when compared to the old basket. The team did, however, receive additional general comments from users that were helpful. Some of the feedback provided was that it would be nice if the forearm section of the handle was wider. This width could be explored further if we were to continue to develop the project.

Other feedback was that when the new basket was held at one's side, it rolled the wrist out a bit. This could also be a factor of the working model being slightly different than the final rendering (Figure 12). Moving forward, it would be helpful to have a model that more closely resembled the final design.



Figure 12: Final rendered design

PROJECT CONTEXT

The studio course, Industrial Design 500: Ergonomics and Human Factors in Design was the forum in which this project took place. It was a unique studio setting for a number of reasons. Foremost, it was about considering the human interface when designing a new product or environment. Throughout the semester the team was constantly challenged to design a basket that met human factor requirements. The team was also exposed to gathering field data. This required studying how designed products are used in an environment and recording data on how humans interact with these products. This varied from other industrial design studio courses because human factors and ergonomics are often considered post-design, or as a secondary part of the design process. The team was also exposed to lab testing, which involved the use of computers and software that used electrodes to test muscle activity. Being able to test a working prototype and be able to test the effects it has on posture and muscle activity are what made this studio a unique experience.

Being on a team also had advantages and disadvantages. Some of the disadvantages of being on a team are that ideas are inevitably compromised. An individual's idea is often made stronger by a group idea. By processing our observations and background research, the team was able to settle upon a final decision. The advantages of working with a group were that it mimicked how design teams operate in the real world,

stressing that ideas are often compromised. Another advantage to working on a team was the fact that each member contributed different strengths and skills to the group. Combining the strengths of all team members resulted in a project that was thoroughly studied, researched, and designed.

ACKNOWLEDGEMENTS

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The authors also acknowledge professors Bryan Laffitte and Bong il Jin for their styling and sketching instruction, which included reviews, critiques, and recommendations. The final models would lack the style and refinement that designers leverage to turn an idea into a product that could be competitive on the market.

Special thanks are also extended to the grocery stores and participating customers who allowed us to collect our initial data and test our working prototypes. These grocery stores include: Whole Foods, the Fresh Market, and other stores whom may have assisted with our data collection.

The project required the use of the RED Lab in the College of Design. The RED Lab is partially supported by the Center for Universal Design, the Ergonomics Center of North Carolina, and UserView Inc.

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2.1.3 INCUBATOR

INCORPORATION OF UNIVERSAL DESIGN PRINCIPLES IN THE DEVELOPMENT OF A KANGAROO CARE SIMULATOR FOR USE IN NEONATAL INCUBATOR

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Problem Statement

Neonatal intensive care unit incubators are sterile, isolated environments. There are no soothing qualities for an infant in an incubator. See Figure 1.

The Problem

Sick and premature babies require intensive care to become well enough to go home from the hospital.

These babies live in sterile, isolated environments.

A vast majority of the touch they receive is procedural rather than soothing, comforting touch.



Figure 1: Premies in incubators

Goal

Incubators provide monitoring and vital life support equipment for premature and ill infants. Skin-to-skin contact of mother and infant (also known as kangaroo care) provides soothing aspects for premature and ill infants as well as providing health benefits as well. My goal is to bridge the gap between the lifesaving

technologies of incubators and the natural benefits of kangaroo care and provide this type of care when parents are absent.

Background

In the womb, a baby rests in a warm, dark, and quiet environment. There is constant communication between baby and mother and familiar rhythms and sounds that engulf the baby.

Premature babies, however, are exposed to un-familiar and over stimulating lights, sounds, and smell much earlier than they are physically and neurologically ready to endure. Because of this, this vital time of growth and development is compromised.

In a neonatal intensive care unit, premature babies receive touch, but it is procedural rather than soothing. The auditory stimulus that is comforting in the womb is replaced with unfamiliar and distracting noises constantly bombarding them.

While incubators provide lifesaving means to premature and sick infants, there are limitations to how modern medicine can help these babies. Infants who have enough muscle development can scoot their body to the side or corner of the incubator to have some contact and sense of boundary within the isolated environment. This contact gives them a sense of security. Not the ideal contact by any means, this boundary at least gives them some comfort in the incubator. See Figure 1.

Research

Kangaroo Care involves placing a diapered baby in an upright position on a parent's bare chest. The baby's ear is placed above the parent's heart. This care was established in 1983 in Bogota, Columbia by Edgar Rey and Hector Martinez.¹ It was found to be a natural, inexpensive alternative to modern medical practices. There were an outstanding number of benefits associated with kangaroo care. See Figure 2.

Kangaroo Care

Kangaroo Care involves placing a diapered baby on a mother or father's bare chest. This care was found to be a natural, inexpensive alternative to modern medicine.

Kangaroo Care has many benefits that cannot be achieved in the incubator alone including to help the babies stay calm to conserve vital energy, creating a bond between baby and mother, and regulated heart rate, body temperature, and breathing rate.



Figure 2: Kangaroo Care

¹ "Kangaroo Care Benefits", Krisanne Larimer. <http://www.prematurity.org/baby/kangaroo.html>

Babies who receive kangaroo care have more regulated body temperature, heart rate, and breathing

rates than babies who remain in incubators. These babies also have more rapid weight gain. Kangaroo care helps babies to fall into a deep sleep which helps to conserve vital energy. Kangaroo care helps the babies to relax and be calm which leads to less crying. Lastly, infants who receive kangaroo care have up to 50% shorter hospital stay. While most studies have proven that kangaroo care has major, positive impacts on babies and parents, some studies have proven there are no changes: but ² no study has proven that kangaroo care has had harmful side effects for either infant or parent. The benefits associated with Kangaroo Care may include decreased costs, increased bonding with family, reduced burden on the hospital, and decreased chance for infection (by being in the incubator).

“Recent research has shown that separation [in incubator] causes adverse effects. Maternal-infant skin-to-skin contact (SSC) provides an alternative habitat to the incubator, with proven benefits for stable preterm infants; this has not been established for unstable or newborn low-birthweight infants.” ³ This was a randomized controlled trial of skin-to-skin contact from birth versus conventional incubator for physiological stabilization in 1200- to 2199-gram newborns.

The simulation of kangaroo care within the incubator can potentially reach those preterm infants who are unstable or low-birth weight.

Harry Harlow conducted a study in the 1950s that involved removing infant monkeys from their mothers, and offered them a choice between two surrogate “mothers”, one made of terrycloth, and the other of wire. In the first part of the study, one group was given the terrycloth mother who provided no food, while the wire mother did. In the second group, the terrycloth mother provided food and the wire mother did not. It was found that the infant monkeys held on to the terrycloth mother whether it provided food or not, and the monkeys would only chose the wire “mother” when it provided food. ⁴ While a contradictory study, these findings are hard to ignore. The need for comforting touch is vital to the development of infants. Harlow himself stated in his book, “It takes more than a baby and a box to make a normal monkey.” ² While not the intention of the incubator, isolation and infrequent comforting touch is a common occurrence in the incubator environment. “Critics of Harlow's claims have observed that clinging is a matter of survival in young rhesus monkeys, but not in humans, and have suggested that his conclusions, when applied to humans, ⁵ overestimated the importance of contact comfort and underestimated the importance of nursing.” Conclusions from Harlow’s study may seem extreme to apply to human infants, yet it is impossible to ignore the findings of this controversial study. See Figure 3.

² Larimer, Krisanne, “Kangaroo Care Benefits”. <http://www.prematurity.org/baby/kangaroo.html> ³ NJ Bergman, LL Linley, SR Fawcus (2004) Randomized controlled trial of skin-to-skin contact from birth versus conventional incubator for physiological stabilization in 1200- to 2199-gram newborns. *Acta Paediatrica* 93 (6), 779–785. ⁴ Harlow, Harry F., “The Nature of Love”. Washington: American Psychological Association, 1958.

⁵ Mason, W.A. Early social deprivation in the nonhuman primates: Implications for human behavior. 70101; in Glass, D.C. (ed.) *Environmental Influences*. New York: Rockefeller University and Russell Sage Foundation, 1968. Excerpt in Stevens, M.L. *Maternal Deprivation Experiments in Psychology: A Critique of Animal Models*. 11; The American Anti-Vivisection Society. 1986. Via http://en.wikipedia.org/wiki/Harry_Harlow



Figure 14. Typical response to cloth mother surrogate in fear test.

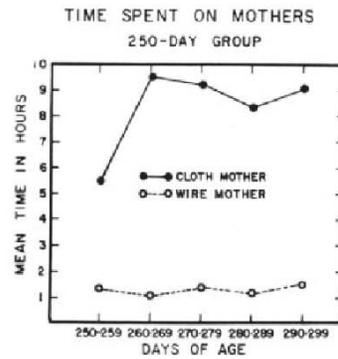


Figure 3: Harlow's Nature of Love



Figure 25. Differential time spent on cloth and wire mother surrogates by monkeys started at 250 days of age.

Market Research

Many products are currently on the market for positioning and soothing infants while in the NICU (see Figure 4). Children's Medical Ventures is a leading provider of products for infants, who are hospitalized, healthy, and premature. These products can be used in hospital settings, the home environment, or both. Zakeez, Inc has a product on the market called "The Zaky". It is an ergonomically designed, award-winning bonding, therapeutic, and positioning product for infants. "The Zaky" is intended for hospital settings.

Product Description



A beanbag positioning aid designed for developmentally supportive positioning. The product can be positioned around the hips, head, neck or extremities.



Snoedel*

A flannel doll designed to absorb the parent's scent and provide babies with a sense of comfort.



Snuggle Up*

A "nest" that helps proper positioning and stability for infants. Once nested in the SnuggleUp, examining, transporting and moving can be preformed with minimal stress and disruption.



Bendy Bumper*

A bendable positioning aid that holds its shape once positioned. Products promote containment, correct musculoskeletal development and positioning, and flexion.



Zaky**

An ergonomic infant pillow designed to mimic the size, weight, touch, and feel of a parent's hand.

* Children's Medical Ventures:

<http://chmv.respironics.com>

** The Zaky":

<http://www.thezaky.com/en/home/index.php>

Figure 4: Market Research

Design Development

The table below contrasts the shortcomings of the incubator with the strengths of kangaroo care to identify opportunities for the KC simulator. Table 1.

Table 1: Benefits associated with care environment or approach
 Kangaroo Care Benefit Kangaroo Care Incubator Simulation

Benefit	Kangaroo Care	Incubator	Kangaroo Care Simulation
Recognition of parent	*		*
Respond to infant's thermal needs	*	*	*
Normal Temperature ⁶	*	*	*
Normal heart rate ⁶	*	*	*
Normal respiratory rate ⁶	*	*	*
Strengthens infant's immune system, through breast milk ⁷	*		
Contact causes calming effect ⁸	*		*
Increased weight gain ⁹	*		*
Enhanced mother-infant bonding	*		Unknown
Restful sleep ¹¹	*		*
Earlier discharge ¹²	*		*
Positive impact on motor development	Possibly		*
Less crying ¹⁴	*		*
Increased confidence of parents ¹⁵	*		
Oxygen		*	*
Monitor Vitals		*	*
Phototherapy		*	*

Note: This KC simulator is being designed with features to take advantage of attributes associated with other care approaches and environments but have not been tested.

⁶ Ludington-Hoe et al., 2005 ⁷ http://en.wikipedia.org/wiki/Kangaroo_care#Benefits_of_kangaroo_care ⁸ McCain, Ludington-Hoe, Swinth, & Hadeed, 2005; ⁹ Charpak et al., 2005 ¹⁰ Charpak, Ruiz-Pelaez, & Figueroa, 2005 ¹¹ Dodd, 2005 ¹² Ludington, Hosseini, & Torowicz, 2005 ¹³ London et al., 2006 ¹⁴ Penalva & Schwartzman, 2006 ¹⁵ NJ Bergman, LL Linley, SR Fawcus (2004) ¹⁵ Tessier et al., 1998; Conde-Agudelo, Diaz-Rossello, & Belizan, 2003; Kirsten, Bergman, & Hann, 2001

KC Simulation Characteristics: Scent:

Scent is one of the first senses to develop and is the first way that babies recognize their parents. Having the familiar scent of a mother calms and relaxes premature infants. This leads to deeper sleep and therefore more energy for vital development. Since the babies are calmer, they are not struggling to get

comfortable within the incubator, thus further conserving vital energy. Incorporating the sense of smell involves the parents to hold the fabric covering of the kangaroo care simulator to absorb their scent into the fabric. There are conflicting opinions about the ability to provide a fabric with a parent's scent on a fabric without introducing bacteria. The solution may be to provide the fabric for scent collection once the parent has scrubbed into the neonatal area.

Movement

Movement helps premature babies with motor maturation, auditory, and visual response, and reduces apnea. The slight movement encourages preterm infants to tense their muscles to counter the movement going on around them. A lot of premature infants lie in an incubator "spread-eagle" with straight arms and legs. This is due to the lack of muscle development to change their position. This slight movement will encourage flexion of their underdeveloped muscles ultimately stimulating muscle development. Movement is introduced in the product in the form of a slim, flat plane housed within the memory foam core. Movement is produced by a simple involute gear system turning a rod with elliptical form on the end to create the rise and fall of the flat plane.

Sound

Providing recognizable rhythmic sounds for preterm infants can also encourage a restful state and help regulate the baby's vitals. Having the sound of the mother's heartbeat helps regulate the baby's heartbeat and breathing rates. Keeping sound to a minimum is important to preventing over stimulation of preterm infants. "Loud, sharp sounds can raise noise levels to 100-200 db, which may damage cells in the ear. ...Loud or sharp sounds can cause physiological changes like tachycardia, tachypnoea, apnea, oxygen desaturation and sudden increase in mean arterial blood pressure, disturb sleep, startle the baby and may even produce intracranial hemorrhage in a micropremiee."¹⁶ The maximum noise level appropriate for a NICU should be 55 decibels.¹⁷ To capture a recording of the mother's heartbeat, an electronic stethoscope will be used to record the heartbeat directly to an electronic device similar to an MP3 player which could be downloaded to a computer. The recorded heartbeat would then be played back in the incubator through the speakers within the simulator. A separate recording of each mother's heartbeat would be recorded for their baby.

Touch

The element of touch is one of the main focuses in current products addressing premature infants today. Touch can be used to create proper positioning and physiological stability. The sense of touch also has an emotional connection. As discussed previously, babies will scoot to the edge of the incubator to have contact with something: to create a boundary to give the sense of security and stability. This sense of enclosure is comforting and in some ways mimics the womb. The bumper on the kangaroo care simulator aids in this important sense of touch. It provides a boundary, support at the feet for a sense of security, and promotion of flexion and correct positioning. The fabric used as the covering is a soft fabric that would either be similar to a high-quality fleece or suede finish. An important aspect of this is that the fabric does not release fibers that the baby could potentially breathe in while in the incubator. Each characteristic can be turned on and off with the control interface that is stored on the outside of the incubator. Each aspect of kangaroo care that is being simulated can be turned on and off whenever needed. Every baby has cues that they respond to best while others may be too stimulating and increase stress. Therefore, it is an important feature to be able to create the appropriate aspects for each individual infant.

¹⁶ Editorial: "NICU Environment: Can we be Ignorant?" Col MNG Nair*, Surg Cdr Girish Gupta+, Lt Col SK Jatana, MJAFI 2003; 59 : 93-95
¹⁷ Altimier, L. "Healing environments: for patients and providers.", Newborn and Infant Nursing Reviews, Volume 4, Issue 2, Pages 89-92

Interface

The user interface is an important consideration in the design. Having a low tolerance for error is important for any design, especially equipment designed for hospitals. A simple and intuitive interface is achieved through universal/ recognizable icons for interactions. A display panel is located along the side of the product with a diagram showing to orient the baby in the kangaroo care simulator. This is to insure that the baby is safely and comfortably interacting with the product. Having recognizable icons reduces error from interpretation of operations. Since the interface is primarily pictorial, users do not have to read the button labels to operate. Assistive access is achieved through the LCD screen on the top of the control panel. If users need further instruction on operation of machine, information can be accessed through the screen. This screen also doubles to display patient information such as info on recording uploaded to the device to insure the correct heartbeat is played for each infant. Buttons are placed far enough apart from one another so that buttons are not accidentally pressed. At the same time, the buttons are oriented together for grouping of activities within the product. A slight rise in the center of the button insures that users have tactile feedback when they press a button. Icons have a glow from under the buttons to illuminate in low lighting as well as to indicate which state is currently selected within the kangaroo care simulator. Figure 5.

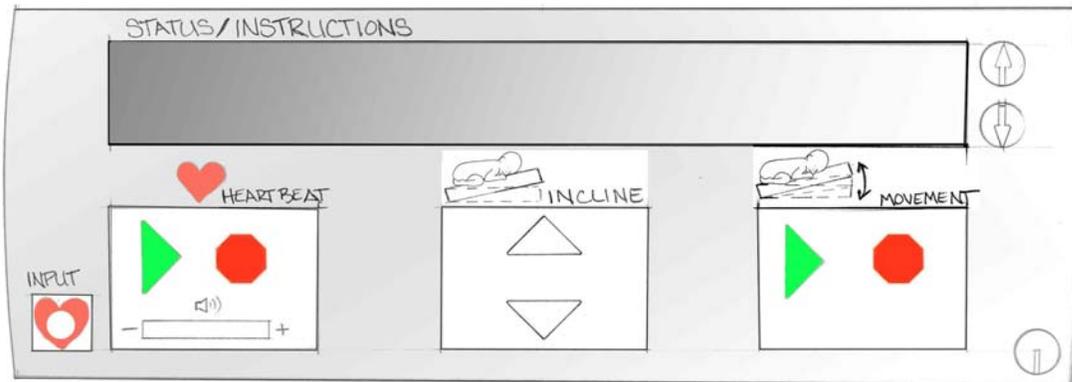


Figure 5: KC Simulator Interface

Process Drawings

The form of the kangaroo care simulator has just as much of a function as the sound and movement that are a part of the design. Form therefore follows function for this product. The form must support correct posture, give a boundary and sense of security, and contain the infant safely, securely, and comfortably. Overall form, angle, and combination of shapes are explored to come up with the final form. See Figure 6.

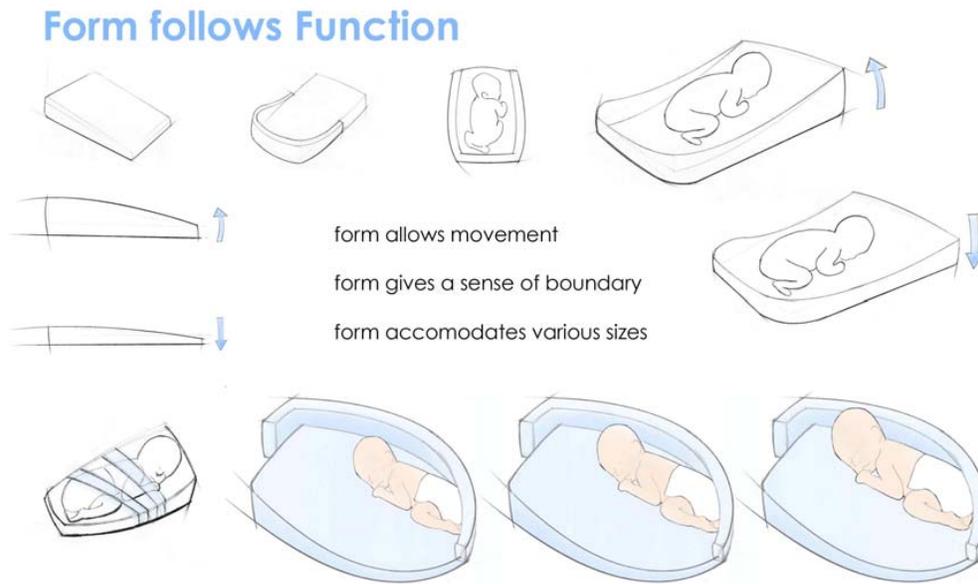


Figure 6: Ideation and developmental process

Materials

Various materials are explored through the design process. The materials chosen below are suggestions and reflex the research of which materials are appropriate for a hospital setting, meet the needs of the user and patient, and are comfortable for the end user.

Antimicrobial Viscoelastic (Memory Foam) core supports baby, create stable laying area, mutes potential sound if internal mechanism to move product as well as the speakers.

Polyester Fiberbill fills bumper for a soft cushion border for baby.

Bacterial, stain, and water resistant fabric (ex. Crypton ultrasuede fabrics) cover for product. Removable, washable, absorbs scent, soft to touch (soothing)

Rubberized layer in area where bumper meets mat. Provides support for bumper to stay in place without noise (as compared to a material like Velcro)

Polypropylene/rubber blend for mechanics to provide movement of product.

Universal Design

One of the overarching sets of principles used while designing this simulator were principles of universal design. The design lent itself to guidance from four of the principles (see Table 2): equitable use, simple and intuitive to use, perceptible information, and tolerance for error. The remaining three principle were consider in the design phase but play a lesser role in the design development owing to the placement of the simulator within existing incubators. These three principles will play a strong role in future incubator redesigns (which is beyond the scope of this student design project).

Table 2: Application of Universal Design Principles
 Kangaroo Universal Design Care Bendy Zachy Infant Principles Simulation Bumper Pillow

Principles primarily influencing design	Equitable Use	Yes	Yes	Yes
	Simple and Intuitive to Use	Yes	Yes	Yes
	Perceptible Information	Yes	No	No
	Tolerance for Error	Yes	Yes	No

Low Physical Effort Size and Space for Approach and Use Flexibility in Use

Final Design

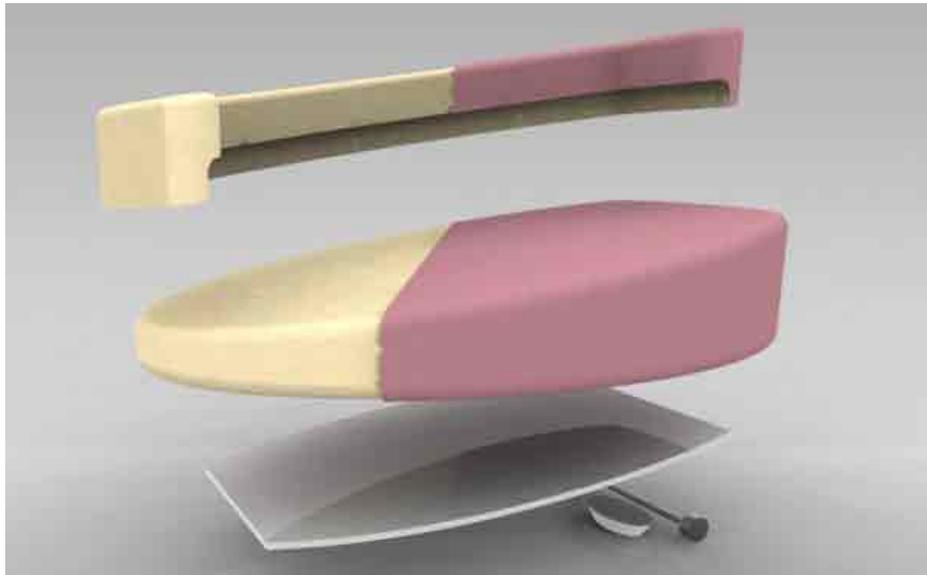


Figure 7: Exploded View of parts and materials

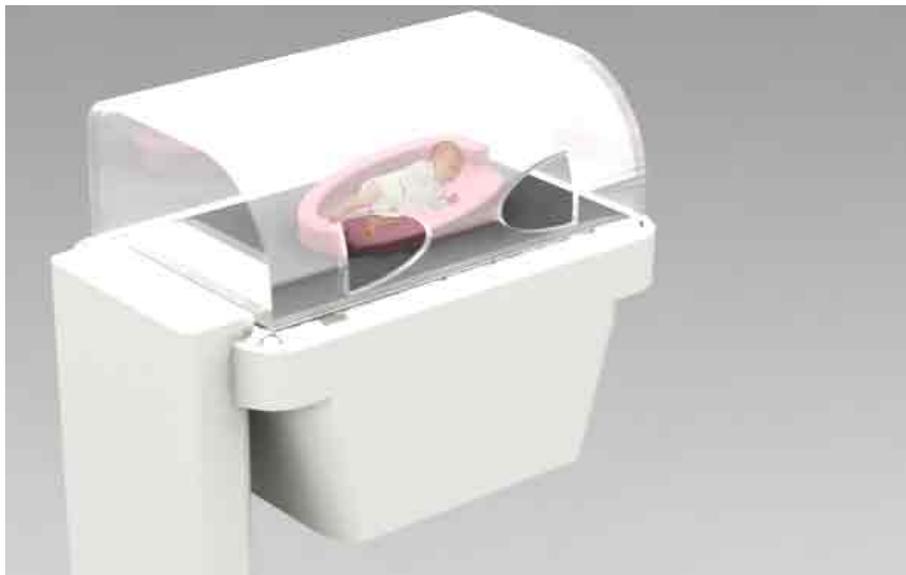


Figure 8: Product within Incubator Environment



Discussion and Future Design Direction

Universal design is an important part of this design and it ensures as many users as possible have their needs met through the design. Many times, design choices are made to meet the needs of the majority, and neglect the needs of the minority. The kangaroo care simulator has a very specific end user in mind that falls into the category of the minority of the population. Special accommodations must be made in order to ensure their best survival and recovery. End users of this product are not only the infant, but also the hospital staff. Universal design principles were applied to both of these users to develop the end product. Infants will receive the maximal amount of benefits with this product by combining the sterile environment, state of the art technology of the incubator with the soothing, comforting affects of kangaroo care. Hospitals benefit from this product as well by having a NICU of calm, relaxed infants who have a shorter hospital stay.

Timeline

ID 200 Studio JPMA contest project (not submitted) ID 300 Studio Project revisited for revision ID 445 Human Center Design Research into human factors and universal design

Note

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2.1.4 BABY BATH STATION

UNIVERSALLY DESIGNED BABY BATH STATION

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Problem Statement

Bathing an infant is a physically demanding task as it requires bending, lifting, and squatting. These known ergonomic risks create an unsafe environment for both the caregiver and the infant. With the prevalence of injury and disabilities⁴ in the caregiver population, a universally designed baby bath tub is needed.

Introduction

Caring for a child can be both physically and mentally stressful. Few resources have been dedicated to developing universally designed products for routine child-care tasks despite the high incidence of musculoskeletal pain, disability and injury among parents and caregivers. Assistive and adaptive equipment provide a means for parents to independently care for their children, ultimately enabling them to provide better care. There are limited solutions created on a small-scale design and marketed to a small segment of the caregiver population.

There are approximately nine million parents with disabilities in the United States, 15% of United States parent population. Parents frequently are unable to bath their own children. (Vensand, 2000) Many of these parents use professional assistance to manage daily child-care tasks, which can be emotionally disconnecting. Parents with disabilities struggle the most with transitional tasks, i.e. carrying and moving belongings. Consequently, simple tasks are time consuming, and increase the risks of stress, fatigue and injury.

Beyond the physical, new mothers face many challenges that compromise their ability to operate optimally. Recovery from delivery can take several weeks. Postpartum stress has also been found to increase the likelihood of developing physical health problems. (Brown, 2000) These stress and fatigues of raising a new child are amplified as women are increasingly faced with the challenge of managing both a career and a family. Stress and fatigue are known to exacerbate symptoms of pain, pain reporting, and risk for injury.

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³ *Assistant Professor of Industrial Design*

⁴ *This includes parents with physical, visual, and intellectual disabilities; deaf parents; and parents with diverse medical conditions.*

Back pain is a common ailment in mothers of infants, and to address this issue, products need to be developed that reduce the strain on the lower back. Studies have found that 44% of mothers experience back pain in the two months following pregnancy (Breen, 1994), and 30% of new mothers report back pain that persists for more than six months. (Russell, 1993) Similarly, in a study of mothers with at least one child under the age of four years, 66% of the mothers report musculoskeletal pain; the location with the highest incidence, 48%, is reported in the lower back, followed by the neck (17%), the upper back (16%), the shoulder (11.5%), and the knees (10%). The ten most physically stressful tasks involved awkward postures as well as bending, lifting, and prolonged squatting. (Sanders, 2002) Childcare workers have also reported that lifting is the most physically stressful part of their jobs, followed by bending. (Owen, 1994)

Adaptive childcare equipment reduces the physical demands and stresses of common tasks and can be a preventative measure against ergonomic injuries. Such equipment is imperative for parents with disabilities, parents or caregivers with temporary disabilities, and grandparents that are actively involved in childcare.

Background Research

Market Research

The most common product available for bathing infants is a small plastic tub (see Figure 1). These bath tubs can be used within a larger bathtub or over a kitchen sink. When used in the tub, caregivers must lean over (extreme flexion of the torso and flexion of the shoulders) and into the tub to bath the child. A similar but less extreme posture is assumed while the caregiver stands when bathing a baby at the kitchen sink. Caregivers also transfer the tub to other surfaces, like the floor, for easier access. These tubs range in price from \$18 - \$40 in the United States.

Little assistive technology is commercially available for bathing infants. Other devices that assist in bathing include thermometers and anti-slip surfaces. External and integrated thermometers help gauge water temperature. To aid in handling babies that are wet and slippery, gloves have been designed to provide a better grip on the child. For parents and caregivers who do not have the mobility or dexterity needed to use these tub basins, the tubs are altered and adapted for use. While searching for assistive bathing devices several retro-fitted tub designs were found. Most commonly, the tub is mounted to a table or cart like the one in Figure 2.



Figure 1. Typical baby bath tub by Primo Baby Eurobath

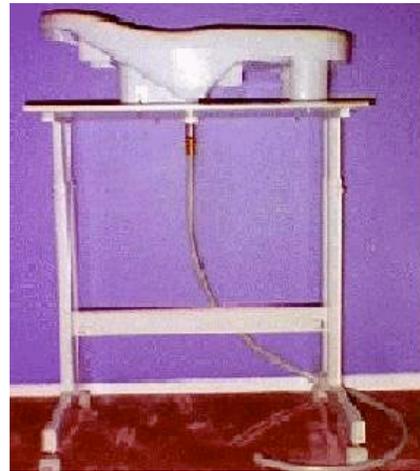


Figure 2. Commercial tub attached to computer table. Drain is connected to dishwasher hose.

This solution provides increased flexibility in use and is intended to create a safer environment for bathing an infant. However, it does not adequately address many of the obstacles faced during the task of bathing a child. Further, this tub set-up requires the caregiver to raise their arms above the lip of the tub, statically abducting the shoulders. Awkward postures combined with protracted static loading are known ergonomic hazards and should be avoided.

Task Definition

Caregivers use a variety of methods to bathe babies. In addition to the standard plastic tubs (see Figure 1), babies are also bathed directly in sinks and are given sponge baths. With each method, there are 10 requirements to complete the task.

1. Preparation of items needed: Since a child should never be left unattended in the bath, all needed items should be prepared prior to the bath and be within reach during and following the bath. Items needed include soap, a sponge or washcloth, a towel, lotion, and a clean diaper and clothes.
2. Lifting and carrying: Both the bath tub and infant need to be lifted and transported to the desired location.
3. Filling tub: In cases where the tub is not beneath a water spigot, the tub needs to be filled in advance, or the water needs to be carried to the tub. Correct water temperature is very important, so that the baby remains warm but is not scalded.
4. Washing: Soap and a sponge or washcloth is needed to gently clean a baby. Fresh water is required to rinse the infant.
5. Safety of child in water: Infants have minimal muscle control and cannot hold themselves up in a tub; therefore, they must be attended at all times. It is recommended to always support the child with one hand.
6. Lifting slippery child: The smooth skin of an infant makes it dangerous to move the child during the bathing process.
7. Drying baby: Some caregivers prefer to dry the child in the tub due to the fact that infants are slippery when wet. Others remove the child from the tub to dry them.
8. Dressing baby: Infants should be dressed immediately following the bath to maintain their body temperature.
9. Emptying tub: The bath water must be drained from the tub. If the tub is not used above a drain, it must be carried to a second location.
10. Cleaning and drying tub: Finally, the tub must be cleaned and dried before being putting away.

The list of requirements and considerations for bathing an infant is extensive, and many steps pose potential ergonomic risks to the caregiver. These requirements become greater obstacles for caregivers with disabilities and/or limited strength and mobility.

Design Solution

The goal of this project was to design a safe and efficient bathing station for caregivers with a range of abilities. This station (see Figure 3) was designed to reduce the amount of required lifting and bending associated with bathing child, ultimately reducing musculoskeletal strain. The design does not require any dwelling modification.

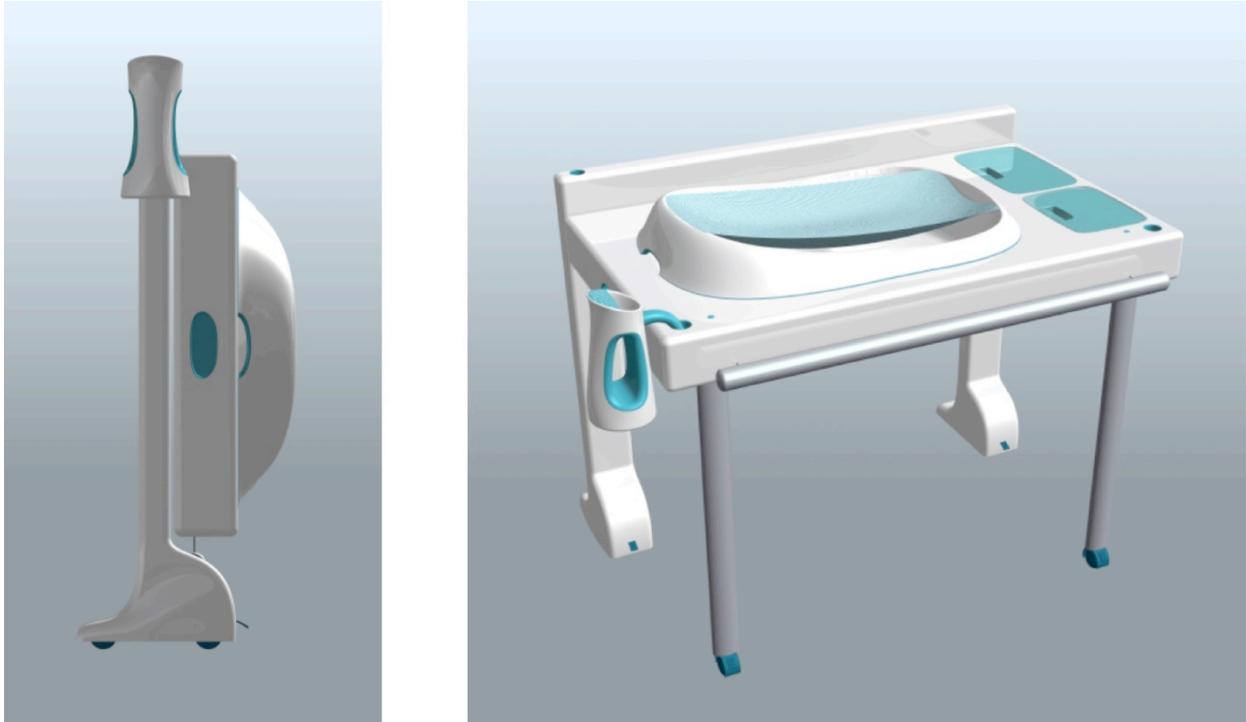


Figure 3. Universally designed baby bath tub.

The bath station is a collapsible table with a recessed bath tub and built-in storage. Designed to be used in any room of the house, the station has an open width of 32.5 inches (82.5 cm). It can fit through most doorways sideways without closing.

The tub basin is gently sloped to accommodate babies up to one-year in age. For newborns and smaller infants, a mesh sling is provided to better support the infant during the bath. The tub can be inserted into the bath station in either direction for left or right-handed users. Like a typical tub, it can be used over the kitchen sink or in a larger bathtub. The built-in color-sensitive thermometer ensures the water is the correct temperature for the baby.



Figure 4. Insulated color-sensitive pitcher.

Two transparent storage containers provide a dry place for clean clothes, soap, and sponge. The storage container tops are flush with the table top providing more working surface area for the caregiver (see Figure 5). These containers are still accessible when the table is collapsed.

An insulated water pitcher (see Figure 4) hangs from the station in any of three convenient locations, depending on storage and usage. The pitcher has temperature sensitive liquid crystals to inform the caregiver that the water is the correct temperature during use. With multiple ways to grip the pitcher, the caregiver can slide their hand through the central hole, or use a power grip. An spill guard is included to control the water flow.

The water is drained from the tub into a water reservoir; a retractable hose can be used to empty the vessel when convenient or when located near a drain. The reservoir can also be disconnected for cleaning.



Figure 5. Close up of side handle and storage

To open the unit, the table top is raised up until parallel with the floor and pushed into a locked position. The table can be lifted with the front towel bar or with the side handles for users with limited flexibility. After the table top has been lifted, the front legs are released with a button; tension springs lower the legs slowly. To close the unit, the front legs are pushed up manually, and the top surface is raised slightly and pulled out (to disengage the lock) before lowering.

The unit is designed to be used while seated. A recessed shallow tub reduces the stress on the shoulders (compared to the moderate to extreme flexion of the shoulders

while using traditional infant tubs). The height of the surface is 31 inches (79 cm), and is ideal for a caregiver seated in a wheelchair, a chair, or on a standard modern toilet.

UD Assessment

This project was undertaken in response to the need to safely support the infant during bathing and to afford caregiver and infant bonding. The comfort and stress of the caregiver may influence the infant's bathing experience. The Principles of Universal Design were used as a guiding tool through the design process.

Equitable Use

The bath station was designed for caregivers with a wide array of abilities and mobility. The station can be used one handed, while seated without straining the back, neck, or knees. The locking mechanisms avoid static loading and minimized strength requirements.

Flexibility in Use

Caregivers can use the station in many ways. To avoid a right hand bias, the bath tub can be oriented in either direction and the water pitcher can be hung on either side. In addition, the station can be left open, or be collapsed for storage in smaller spaces. A caregiver can sit on the side of the station with the baby facing them, or sit with the baby horizontally in front of them.

Simple and Intuitive to Use

The design's mechanisms are common and easy to use. Little concentration is required to open and close the unit leaving the caregiver's attention to focused on the infant.

Perceptible Information

Contrast was employed to help accentuate the forms and identify areas that a caregiver will touch. For example, the pitcher is colored on the areas to hold, and the rubber drain plug is colored to distinguish it from the bottom of the tub.

Tolerance for Error

Color-sensitive temperature displays on the pitcher and tub highlight to the caregiver the water temperature. Temperature extremes may either scald or draw body heat from the infant.

Low Physical Effort

The unit can easily be opened, closed, or moved with one-hand. Since it is lightweight and on wheels little effort is required to move and store the unit. The load on the back and neck are greatly reduced because of postures assumed while using commercially available infant tubs.

Size and Space for Approach and Use

Size and dimensions were of particular interest in this design (see Figure 6). Table height was calculated based on hand and elbow locations while caregivers were seated

in a wheelchair, chair or on a toilet bowl. The unit was also designed to fit through a doorway without being collapsed. At the same time the unit needed to be deep enough to accommodate a seated person bathing an infant from the side of the unit. Finally, it was imperative that a user could open and close the unit with one hand and without bending.

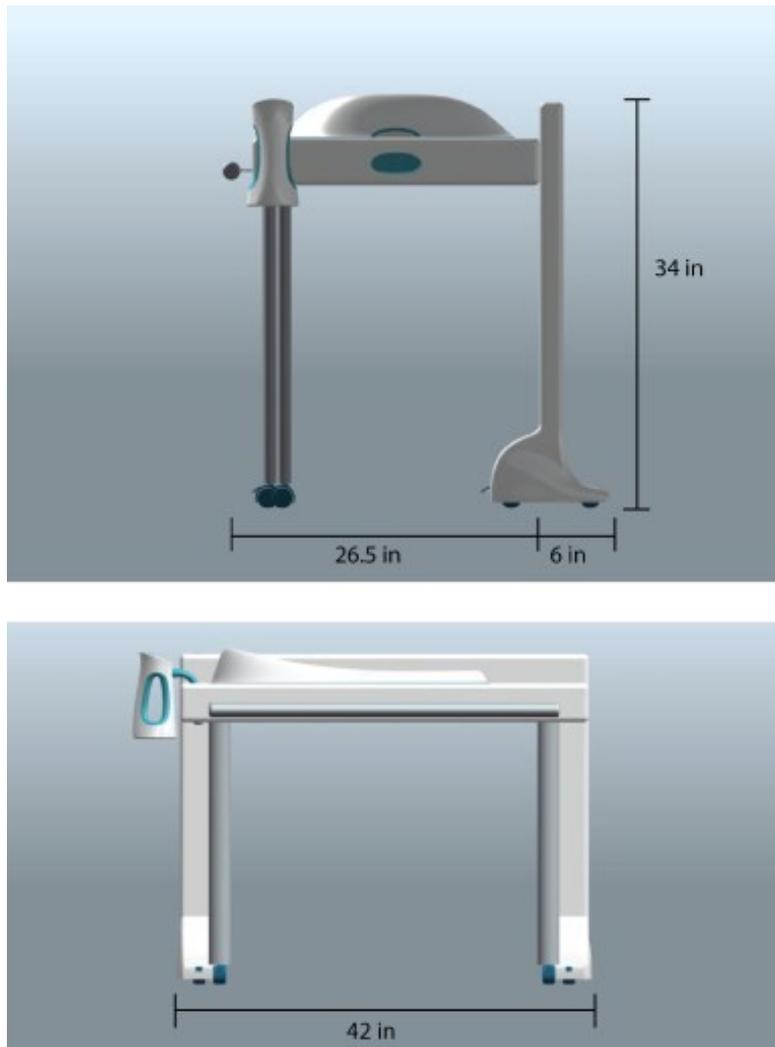


Figure 6. Measurements of bath station.

Conclusion

The design successfully included the Principles of Universal Design in an infant bathing tub. Investigations into the feasibility and cost of adding adjustable height legs in order to comfortably accommodate users of different heights. To minimize shoulder abduction while maintaining a safe and dry environment, further exploration is needed to identify the ideal height of the tub lip. Operational icons are being considered to increase the tolerance for error.

The infant bath tub was designed to provide a product for bathing a child that will benefit all users. It will afford caregivers with musculoskeletal injuries, limited mobility and strength, as well as temporary and long-term disabilities increased comfort and security while bathing infants.

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2.2 UNIVERSAL DESIGN EXHIBITION

The Center for Universal Design at North Carolina State University is currently developing an exhibit to showcase the seven Principles of Universal Design. The principles, published in their current form in 1997, serve as the theoretical guidelines for universal design, providing a set of goals for designers in all fields to achieve in their works. Unfortunately, though, the principles often do not make their way into the conversation of the client or consumer. By developing a traveling exhibit, the team at the Center for Universal Design hopes to continue their efforts to increase awareness of issues surrounding and integral to Universal Design, especially issues encountered in the home environment.

Overview

In beginning to develop the exhibit, the design team, led by Sean Vance, AIA, were confronted with a major question regarding the approach designers take to universal design: “Should it be a set of guidelines, or should it be a series of questions to ask



Figure 7 - Students and young architects evaluate a potential case study house under construction.

yourself or your clients?” In choosing the latter option, the widely publicized Principles of Universal Design provides a starting framework for the exhibit’s content. Accompanying the principles are displays explaining the history and development of universal design as a philosophy, a map of the concepts, entities, and relationships across the field of universal design, and a display of work examples from researchers, students, and professionals involved in universal design based initiatives.

An exhibit with a purpose

Focusing their efforts, the design team chose a familiar target for their research: the home environment. The exhibit focuses primarily on the use of the principles in shaping both single- and multi-family properties. In developing the exhibit, the design team continually questioned the assumptions of occupancy common to the

design of contemporary housing by hosting a series of discussions to investigate the shortcomings of current housing typologies with students, educators, and professionals to provide feedback.

The exhibit is, of course, intended to inform the general public, but targets designers specifically, asking them to evaluate their own design processes. “The goal of the exhibit” says Vance, “isn’t necessarily to provide the answers. Instead, what we would like to do is provide an appropriate set of questions to get designers thinking about Universal Design.” This approach is designed to spark new innovations among designers that will then lead to more accessible, inclusive spaces and products, just as the publishing of the Seven Principles did more than a decade ago.

The Seven Principles

The Seven Principles are widely acknowledged as the theoretical guidelines for designers wanting to create more inclusive products and spaces. Through these products and spaces, consumers more often feel their influence, rather than understand the principles themselves. The exhibit team hopes to change that by creating a display that showcases each of the seven principles both individually and as a collective approach to design. Each principle is allotted a board that defines the principle and begins to demonstrate its application at a variety of scales. This range is illustrated through a series of small case studies and examples from the relatively small-scale design of handheld products to large-scale urban planning projects. The primary focus of the examples, though, keeps with the immediate focus of the exhibit: the home environment. Exhibit guests are introduced to the definitions of the principles as well as their potential applications in the home through improved control systems, spatial plans, and products.

Concept Mapping

The portion of the exhibit that is perhaps most intended to be the cornerstone of the exhibit’s message is a map of concepts and entities associated with universal design. As Vance states, “We want it to be understood that choice is about connecting in a bigger world... a world that is connected to Universal Design.” To that end, entities are grouped by function or type, and then linked to organizations or entities with similar goals or recognizable links. In this way, observers are able to distinguish both direct and indirect connections between individuals and organizations. Viewers may, for example, examine the links between funding



Figure 2 - Nikhil Shah arranges map elements to reinforce connections.

sources, research organizations, organizations that disseminate the knowledge generated from that research, designers, and the household products and environments they encounter every day.

More than a conversational piece, the map also provides a unique resource for both designer and consumer. As Art Rice, professor of Landscape Architecture at NC State's College of Design notes, the map can be used "to help people understand the whole community of universal design, and where to go and get resources." These resources are not solely funding sources for researchers, but various organizations whose primary goal is to distribute information about the concept and implementation of universal design in fields ranging from web design to industrial design to architecture and landscape architecture. "The other thing that's nice about seeing this," notes Rice, "is to truly get a sense of the complexity and the number of organizations involved in this. ... And also, that there's all these other kinds of things like psychology that [designers and clients] don't think about directly."

Chronology

The exhibit not only highlights the current applications of universal design, but also its past with the inclusion of a timeline displaying the history of various individuals and organizations that influence universal design. The timeline begins as early as the fifteenth century with the works of Leonardo DaVinci, but focuses primarily on the near-exponential growth of universal design as a field of study over the past half century. The chronology notes key milestones in design and building practices with the passage of legislative measures that encourage accessibility, including the Americans with Disabilities Act and the Fair Housing Amendment. The design team is attempting to include as much information in the chronology as possible. Says Vance, "It's a timeline not only of universal design, but also a timeline of [human factors]. ...We're going to place all the things that are on the map on the timeline."

Interacting with Universal Design

The exhibit includes an overview of a large body of information relative to universal design, but the design team's goal is also to make the concepts behind this information tangible to the public. To help accomplish this, the exhibit includes a display of work from students, educators, and professionals that the team hopes will help visitors relate to the wide range of approaches to universal design. Student work from the College of Design is displayed alongside that of professionals, showcasing a wide exploration of materials and approaches to usability. To further enhance the display, RED Lab, an ergonomics lab created as a partnership between the Center and the College of Design's Industrial Design Department, will provide a series of interactive displays for visitors to experience firsthand involvement in the process of design and ergonomics research.

Next steps

While the finished exhibit is designed to reach across the perceived boundaries of a traditional museum exhibit and involve its visitors, the process of developing the exhibit is also designed to reach across disciplines. Sean Vance, as project head, is working with NC State's nationally recognized Graphic Design Department to involve students in the design of the final graphic layout for much of the exhibit. Students will take the design team's exhibit prototype and develop it into a more refined, travel-ready exhibit over the course of just a few months.

The exhibit is tentatively scheduled for display at both North Carolina State University and the University of Virginia in early- or mid-2010.

CHAPTER 3

THE DIRECTOR'S MESSAGE: OUR 2030 INITIATIVE

U. Sean Vance, AIA

The concepts of universal design are increasingly discussed as a part of the collective of issues facing the next generation of designers. Of these considerations, the first would be how design education is preparing them for advancing the quality of life through the design of products and environments. Over the years North Carolina State University's College of Design has been a core contributor to the increasing body of knowledge with regard to the applications of this philosophy in various design communities. With the presence of so many working in design related disciplines across a global construct, and the cogency associated with the development of design understanding and application, the College of Design's Center for Universal Design is working toward further definition of the core principles that established its presence in the design community.

With individual healthcare spending expected to rise in the coming year, and a growing trend of populations living beyond current life expectancies, alternative solutions will need to be found that increase the quality of life and better environmental health conditions while decreasing the impacts of daily life. A connection of the necessity of design as contributing to the betterment of the current state of physiological and psychological approaches on health, and working solutions to overcome the barriers of our varied abilities in the greater built environment due to a variety of health factors. Design solutions to these prevalent problems cannot remain reactive, only preventing a worsening of the current state, and evaluating symptoms as they occur. The majority of the research regarding universal design is generally associated with bad practices on an individual basis or associated with the current response to design standards and codification of processes. The lack of studies of the design processes have greatly limited the awareness of the how to create both artistically and socially conscious solutions while increasing design equality. Along with the efforts in general design awareness there is a need for public understanding of the economic return from universally designed products and environments for private and public financial institutions as well as corporate and commercial interest. In order to establish this proactive approach it is important to increase the involvement of design as a leader in the role of planning these efforts.

Design, as a process, looks at the entirety of considerations necessary for the successful implementation of change, a change that globally impacts all things built or manipulated by human intervention. Design, as leadership, is the realization that all processes of creation begin somewhere, is a connection the idea and its fabrication, and that the creative process must constantly involve the understanding and

consideration of human factors both individually and globally. The Center for Universal Design is constantly reflecting upon these considerations, and is working towards bettering the quality of human experience and health related issues; it is a step toward the creation of a Healthy Built Environment.

Why it is important to our professions and students?

The challenges from one generation to the next in the understanding of human physiology introduce new design dilemmas and constraints that designers must respond to. The continued assessment of accessibility guidelines responds to the variations of limited human ability, but the accomplishment of better solutions will be the result of the design community's passion for change and a shared vision towards a better built environment. Universal design can now broaden its association with the arts and design, moving beyond addressing only the limits human ability into a holistic human centered design approach.

The history of Universal Design at NC State University's College of Design began as a collaborative effort for change as early as the mid-seventies. Research into how architects, graphic designers, and industrial designers provided an understanding of usability that engaged emerging accessibility issues even at that time. These were the beginnings of a design understanding that brought about the removal of barriers and the leadership of many individuals who shared a common vision across varying professional perspectives, acting as one.

The importance of design education that continues to explore the principles, strategies, and application of universal design as an ideology for designing products and environments, responds to the need in the College of Design and all universities for information and skills relative to human centered design thinking. It is a process that includes a broadening of the student's awareness of evolving human and environmental characteristics, and how to contribute to advances in universal design concepts for design, manufacturing, communications and construction.

As a result of the College of Design's continued work in universal design, our students continually demonstrate the knowledge and application of design ideologies that benefit a universal design approach. This heightened sense of design compassion creates artistic inquiry that is aware of the impact of the environment on human function and will understand the design implications when developing solutions; developing creative explorations that equally meet the needs of people with varying physical and psychological abilities along the natural range of human performance that can include variances in sight, hearing, movement, and cognitive processes.

Working towards the Future together

NC State University recognizes the importance of design to enhancing health and well-being and as a major university and research focus area, the College of Design identifies the area of Universal Design as a priority for the future. This presents a

significant opportunity to integrate and expand public awareness of academic, research, and extension design efforts to serve the most pressing needs of a global citizenship. In working toward the tangible efforts needed to provide education and research that enhances the understanding of design on health and well being, the Center for Universal Design has consistently been a resource providing a variety of research and engagement activities. Some of our recent community outreach events have included:

- **Sight, Sound, and Motion.** For close to 33 years this annual event at the College of Design has provided an awareness of the difficulties associated with physical barriers on people with limited physical abilities. The Center for Universal Design has expanded the influence of this workshop offering it outside of the College to professional organizations and other community oriented organizations.
- **Design Education.** The College of Design continues to engage the importance of Universal Design in design education and the creation of healthier environments with the inclusion of the Principles of Universal Design into the expanded first year curriculum for the College, and addressing the design of healthier products and environments. The Center is also working on a three part educational program titled 'Universal by Design'. This program will begin in the classroom with a seminar program and future studio course that will be open to the greater college and university. The program will also include a professional and community oriented certificate process, and a globally marketed online course.
- **Public Awareness.** The Center's staff continues to participate in public and professional symposiums and workshops around the state, nation, and global community promoting the importance of universal design awareness. Sharing with communities the goals and application of the principles, and building collaborative relationships that will help to extend the outreach we offer through our efforts at the College of Design.
- **Informative Outreach.** The publications and technical sheets produced by the Center of Universal Design have been particularly helpful in providing practical solutions to the everyday design dilemmas facing our communities. The presence of the Center, available through the website and publications, has been helpful in providing continuous availability of information and resources to a greater audience; raising an awareness of the need for primary accessible environments in places around the world with limited resources and capabilities.
- **Ergonomic Understanding.** The Center also provides space for research and collaboration with the Industrial design program studying the ergonomic impacts upon obese and aging populations. The research and development of the obesity suit and the aging restraints help to raise awareness to the design needs associated with these growing design considerations.
- **Next Generation Universal Design Home.** The Center will continue to provide design solutions through the continued research of the Universally Designed Home.

Addressing contemporary issues of gender, age , and population changes facing future North Carolina residents.

An empathetic designer is one who understands of the social and psychological reality that the human condition is continually in a state of change, and that it is critical for the practice of universal design to become a reality in the development of social equality. This relies on the academic offering of research to advance the public well-being tackling the broad impact of how the built environment shapes human behavior, impacts feelings of success and competence, and fosters community connection. The establishment of a stronger research engine for this endeavor within a college of design will serve as a mechanism to expanding the influence of design on the state of global human and environmental health, establish a greater discourse internally and externally in the academic world, and communicate directly with the public and professional surroundings where this information is needed the most. The first of these requires a strong internal connection between academic and professional contributors in universal design. A library of information, processes, and research with a true foundation in the Design Arts is needed connecting all to a process of simulation, theoretical pursuit, and outcomes that will constantly engage the design, implementation, and evaluation of components in the built environment.

By fostering interdisciplinary and inter-institutional relationships to study solutions for human factors through design, the research is strengthened, and the solutions made viable for greater implementation in a global economy needing proof of application prior to consideration. This collection of resources from the Center for Universal Design will continue to grow stronger through the holding of a series of outreach symposiums, primarily serving as a working environment for developing competent communication. The Initiative will engage academics and professionals together in discourse of how best to begin, and equally what do they need to better their own efforts towards betterment in the design arena.

We pay tribute to Ron Mace and thank him for his vision.

Contributors

Sean Vance received his Bachelor of Architecture from Tuskegee University and Master of Architecture from North Carolina State University. He is the Director of the Center for Universal Design, Extension Assistant Professor of Architecture and Landscape Architecture in the College of Design at North Carolina State University.



Sean is a registered architect, teaching courses focused on a human centric understanding and the experience of a collaborative design philosophy. His interests are in universal design, architectural design, urban spatial form, conceptual product design, and research in the effects of form on human interaction and function of daily life.

Sean has taught a series of courses and studios in architecture and most recently a cross disciplinary course in the College of Design. This interdisciplinary course analyzes the interaction between people and their use of the environment in which they live. This is a philosophy that he embraces both academically and professionally, sharing with students and colleagues the pursuit of solutions responsive to the way people live within the constraints of their abilities. Most recently Sean has taught architectural studios on Urban Design that reflect upon Universal Design by having students analyze their solutions through the Center's Principles of Universal Design and the AIA's Principles for Livable Communities. Sean also works with students compiling an understanding of materials and material applications responsive to human senses to create a materials library. This exposes young designers to a language of experience for applications in universal design. Sean brings to the Center 15 years of architectural design experience, and his work has always been from perspective of the user, instinctively deploying the fundamentals of Universal Design.

Before joining the Center for Universal Design and School of Architecture faculty, Sean had been practicing architecture in a variety of communities throughout the East Coast and in 2004 began his own practice. Sean is a graduate of NC State's Master of Architecture program where he studied architecture and industrial design and was a member of Tau Sigma Delta. Sean also serves the architectural community through his participation at the state and national levels of the American Institute of Architects.



Sharon Joines received her B.S, M.S., and Ph.D. in Industrial Engineering from NC State University. She is an Assistant Professor of Industrial Design, Researcher for the Center for Universal Design, a PhD faculty member for the College of Design and Director of the Research in Ergonomics and Design Laboratory (redLab).

Sharon Joines is a researcher and ergonomist, teaching courses in human centered design and ergonomics. Her interests reside in universal design, applied product and process research, and the effect of aging on fatigue development and work. Her research focuses on quantifying the interaction between individuals, products, and their environment. Sharon works with engineers and designers in all phases of the design cycle. The challenges they have addressed traversed consumer markets, warehousing and distribution, medical applications, and manufacturing environments ranging from forging to clean rooms.

Before joining the faculty in Industrial Design and the Center for Universal Design, Sharon was the director of research and education at the Ergonomics Center of North Carolina. She was a John T. Caldwell Scholar, Merit Scholar, University Scholar, and NC Fellow. She is a member of the Order of Thirty and Three, Alpha Pi Mu, and the Human Factors and Ergonomics Society.

Ashley Vercoe received her Bachelors of Industrial Design from North Carolina State University. She has worked as a research assistant for the Center for Universal Design at NCSU, an Industrial Design intern at Human Centric Technologies and as 3D modeler for DELTA at NCSU. Ashley is currently interning at SiTEL, which is an innovative, forward-thinking division of MedStar Health whose focus is on simulation training in the medical arena for ER's, OR's, and mass trauma training. MedStar Health is a non-profit organization that oversees 8 hospitals in the Washington, DC and Baltimore areas.



Andrew Peeler received his Bachelors of Industrial Design from Appalachian State University and is currently a Masters student in Industrial Design at North Carolina State University. Drew has worked as a design intern at Saucony and Enventys. He has worked as a teaching assistant for an advanced Human Centered Design course and is a research assistant in the Research in Ergonomics and Design Laboratory (redLab).



Andrew Cherry is both an alumnus and current student of NC State University's College of Design. After receiving his bachelor's degree in Industrial Design, he worked for a designer and manufacturer of eco-sensitive concrete products. Always intrigued by the interactions of people and spaces, he returned to the College of Design to pursue a Master's degree in Architecture.

Nikhil Shah is a recent graduate of the Bachelors of Environmental Design from the College of Design. He will be working with firm Estudio Teddy Cruz this year, and will return to NC State University to receive his Bachelors of Architecture the following year.



Ines M. Palacios is a PhD student and Research & Teaching Assistant in the Parks, Recreation, and Tourism Management Department at North Carolina State University. She plans on graduating 2010. In the recent past Ines has interned with the National Institute of Environmental Health Sciences(NIEHS/NIH) in the Office of Management.

Erin White is currently a Master's student in Architecture at the College of Design. He works as a teaching assistant and serves as the president of the Graduate Students in Architecture. He received his bachelor's degree in Biology and Environmental Studies from Bowdoin College, and before enrolling at NCSU Erin spent four years working as an architectural designer at utile, inc, of Boston MA.





Danielle Lake is a recent graduate from the 4 year Bachelor of Environmental Design in Architecture program at NC State. She will be returning to the College of Design in the Fall for the 5th year Bachelor of Architecture program.

Ryan Wallace is a Track 3 Master's of Architecture student. Prior to moving to Raleigh, Ryan lived in Salt Lake City where he received a Bachelor's degree from the University of Utah in Urban Planning. A virgo, he enjoys long walks on the beach, curling up with a good book, and hot chocolate by the fire. One random fact about Ryan is that he lived in Sweden for two years where he became fluent in Swedish.



Kathryn Asad is a design student working on her Masters of Industrial Design at North Carolina State University. She is on staff at the Museum of Art in charge of Planning and Design. Kathryn took fourth place in the NY International Auto Show's World Traffic Safety Symposium Design for Safety Competition for her design Flashback. She caught the attention of many for her realistic Desk-Chair combo submitted to the LG Surfaces Beyond Design Challenge.