

Proposal for establishing the:

Wearable Product Design Center

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Type of Center:

The Center is proposed as a Collegiate Center within the College of Design:

A Collegiate Center is an entity established to support and advance research, education, or public engagement that includes mostly members from the same college. From: UMN Administrative Policy, Creating & Evaluating Interdisciplinary Centers
(<http://www.fpd/finop.umn.edu/groups/ppd/documents/policy/interdisciplinary.cfm>)

Vision and Need

The Center is envisioned as an innovative, synergistic "think-tank" to explore methods and technologies that will change how we design, produce, and wear clothing. In a changing world those who address the basic needs of food, shelter, and clothing must provide innovative products and services to address needs and improve quality of life. The Center will focus on one essential need—clothing---expanding the description to “wearable products” that encompass everyday clothing, protective clothing and equipment worn in extreme environments and hazardous situations, medical and health products such as monitoring devices and prosthetics, and more. Research will also address human needs related to appearance and aesthetic responses to clothing. By synthesizing the experience and expertise of researchers with disparate foci and backgrounds, synergistic efforts will be made possible that address in new ways the function and shape/size of the human body, the form and function of the wearable product, the perceptions and psyche of the wearer, response of those viewing the wearer, methods of manufacturing the wearable product, and environmental effects of production, use and disposal of the product.

Research project examples may best demonstrate how the Center will address changing needs and the potential of providing new directions, methods, and solutions for industry and education. We consider the possibilities of addressing needs from within the human (psychological, emotional needs) to the surrounding society and culture and to the systems used to produce wearable products.

- Obesity is a major public health issue in the United States. Center researchers have conducted two studies on weight loss and apparel fit. Apparel fit and satisfaction with

appearance could be a major motivator in encouraging weight loss and healthy eating. Further research in this area is warranted.

- Body image is closely related to the physical appearance of a person. Pervasive media messages (entertainment, advertising, fashion magazines) affect body satisfaction, especially of young women. An on-going project funded by the University of Minnesota Institute for Advanced Studies addresses how young women view their bodies in relationship to real, healthy body forms (illustrated with body scanning). The project demonstrates the researchers' interest in collaborative research with work on the project involving experts from psychiatry, psychology, computer science, medicine, and graphic design. The research team is developing a body satisfaction intervention to counterbalance unhealthy media images.
- The need for improved health care and medical products will increase as the population ages. Center researchers are studying the healthy aging body and proposing adjustments in sizing systems to improve fit of ready-to-wear apparel. They have also studied the effects of osteoporosis on body shape and form, proposing methods of improving designs and improving quality of life for women who have severe osteoporosis.
- Continued U.S. involvement in military actions across the world has increased needs in other areas, for instance the need to improve prosthetic design and fit. The HDL conducted a project addressing specific needs of prosthetic design and fit for lower limb amputees. A clearer understanding of the relationship of the body to a wearable product is not just an issue of appearance, but can be crucial to function and comfort.
- The HDL and the Wearable Technology Lab have innovative, cutting edge technologies that are being used to address design problems in unique ways. To our knowledge our undergraduate students are the only U.S. students using body scanning and digital draping to understand the foundations of apparel design. With this background, we believe that our students will lead the industry in developing faster, more cost-effective methods of designing and producing apparel. Likewise, our undergraduate and graduate students have the unique advantage of analyzing wearable products in motion using two motion capture systems and a dynamic mannequin. While the technologies were acquired to advance research programs, the researchers are also invested in using the technologies in teaching.
- Research in wearable technologies for body monitoring in the Wearable Technology Lab focuses on the development of wearable body sensors that achieve functional accuracy in everyday, comfortable garments. Such technologies will be instrumental in achieving pervasive healthcare monitoring for aging, remote, and underserved populations, as well as for markets like sports, gaming, and next-generation computing technologies.

- The Wearable Innovation Studio provides resources to develop innovative approaches to the form and function of wearable products. New technologies and new applications of traditional methods create a synergy of possible design solutions. This approach is also used in our undergraduate program with students using CAD technology and traditional methods of developing garments and creating surface design to develop design solutions for a variety of end users.
- A major issue in all design fields is sustainability. In classes such as History of Dress, Innovation Theory, and Aesthetics of Dress we discuss topics such as the design and user perceptions of dress within the context of eco-design and sustainability. An ongoing Wearable Technology Lab research project takes a guilt-free approach to encouraging sustainability in the form of a Smart Wardrobe system that recommends novel outfit combinations of underused garments, replacing the novelty gained from purchasing new garments with novelty achieved through new combinations of existing garments. Center researchers will build on these current teaching and research topics in sustainability.

Center Research Personnel

Four full-time tenured/tenure track faculty are the core researchers for the Center (cv's in appendix A) and provide direction and focus for the Center's research programs based on their backgrounds, individual and collective expertise, and established research programs. Current facilities include four labs and a studio. The research conducted in the areas focuses on the research capabilities of each researcher while allowing flexibility and encouraging collaboration. Current researchers have collaborated on several projects. We also see the flexibility of bringing in other researchers from the college with research and teaching backgrounds, specifically in product design, retail merchandising. The following sections outline the existing areas of expertise that will form the initial core of the Center. However, as the value of the center lies in collaboration between researchers with diverse apparel-related interests, it is not dependent on these specific component laboratories.

The Human Dimensioning© Lab (HDL), established in 2004 with a *National Science Foundation grant* visualizes, assesses, and measures the human body to better understand methods of providing physical and psychological “fit” of wearable products. Examples of recent cross-campus interdisciplinary projects in the HDL include space suit design with physiology and psychology through the Laboratory for Human Performance in Extreme Environments, body satisfaction intervention with psychiatry and psychology funded with an Institute for Advanced Studies grant, and amputee limb volume assessment with physical medicine and rehabilitation working with a prosthetic student from Century College who is now a graduate student in the UMN Medical Devices Center. Since its inception the HDL has employed 6 research assistants and one research associate (a physical medicine and rehabilitation physician). The HDL serves as an educational center for undergraduate and graduate students in apparel design who are interested in the latest

technologies in body imaging and apparel modeling. Human Dimensioning© Lab research coordinator: Karen LaBat.

The Wearable Technology Lab brings a new element to the College of Design incorporating the research of assistant professor, Lucy Dunne, with collaborative connections to Mechanical Engineering, Computer Science, and Electrical Engineering. The research interests of this lab focus on translating the theoretical potential of smart clothing and wearable technology into products that function within the constraints of the everyday world: for specialized applications like pervasive medical monitoring as well as mass-market applications like device interface, sports and fitness. Recent research in the Wearable Technology Lab investigates the intersection of technology and clothing/worn products in traditional garments through the development of a “smart wardrobe” garment tracking and recommender system, in virtual worlds through exploration of emerging virtual clothing and fashion design in Second Life™, and for future smart clothing development in investigation of garment-integrated wearable body sensing. Wearable Technology Lab research coordinator: Lucy Dunne

The Experiential Laboratory addresses research relating the materiality of wearable product design to an individual’s perception of the product and how he or she values the product in terms of preferences, knowledge, and experience. This research involves consideration of the context of the wearable product, that is, its relation to the historical moment, to the culture and trends that surround and influence the wearable product and its use. Recent research investigates the intersections of wearable products to models of consumer value, of perceptions of sustainability in the apparel we wear, and how the apparel industry is perceived in terms of present and future responsibility, how design communicates its sustainability, and finally, how the consumer values products that are recycled, reused, and repurposed. The Experiential Lab also incorporates and expands the ground-breaking research on aesthetics related to apparel by Marilyn DeLong and detailed in her well-known book, *The Way We Look*, and in her continued published works. Experiential Lab research coordinator: Marilyn DeLong

The Wearable Innovation Studio provides equipment and space for collaborative development of wearable prototypes using current and developing technologies. The basic equipment for prototype production was acquired with the HDL *National Science Foundation* grant and is housed in the HDL and in an adjacent materials test space. The goal of the studio is to use practice-led research to address issues at the intersection of formation and performance of prototypes. A current project, supported by an *Imagine Fund* grant, is to explore and evaluate ultrasonic welding technology for applications that extend beyond its traditional use in low cost medical and industrial applications. A past project, currently under patent application, uses an adaptation of Shibori, a traditional method of pleating fabric to create surface texture. This concept was transferred to improve the fit of a personal protective suit for pesticide application. Materials testing

and formation research complement the activities in the other labs in the Center.
Wearable Innovation Studio research coordinator: Elizabeth Bye

Center Directors:

Karen LaBat and Elizabeth Bye will serve as the co-directors for the Center. They will have administrative responsibilities and coordinate projects for the Center.

Supporting the Mission of the College of Design

The mission of the CENTER relates to the College of Design Mission to be an international and national leader in multidisciplinary research, creative production, teaching, and public engagement. The investigators in the proposed Center are nationally and internationally recognized in their respective areas of scholarly work with refereed publications in many journals including: *Australasia Medical Journal*, *Clothing and Textiles Research Journal*, *Ergonomics*, *Fashion Practice*, *Fashion Theory*, *International Journal of Clothing and Textiles Technology*, *Journal of Applied Ergonomics*, *Journal of Fashion Marketing and Management*, *Journal of Neuroengineering and Rehabilitation*, and *IEEE Transactions on Biomedical Circuits and Systems*.

Researchers in the HDL received the *Lectra Innovation Award for Faculty Research* in 2007. By establishing this Center we will provide a venue for continued success and collaboration and will continue our efforts to establish linkages with colleagues locally, nationally, and internationally. The Center will also provide a network and structure for developing and evolving the College of Design Interdisciplinary Product Design Program and researchers willing to collaborate with the in-coming product design assistant/associate professor. Although this person will not be focused on wearable product design, a network of established researchers in the Center can help guide a new researcher in the college, and perhaps provide a space for collaboration and brain-storming on research and teaching.

The Goldstein Museum of Design offers the opportunity for research with its extensive archive of historic dress. The breadth and scope of this Museum offers a unique opportunity as a university collection and archive. The historic perspective is essential in understanding developments and transitions in apparel design, technology, and production.

Center Connection to Land Grant Mission of Teaching, Research and Outreach

Teaching

Researchers in the Center contribute to the teaching mission of the University. In the past 4 years the HDL has provided the newest technologies and mentoring to doctoral students who are now on faculty in U.S. and international colleges. A goal will be to attract graduate students of excellence from a range of disciplines. Bye, Dunne, and LaBat are adjunct faculty in the proposed Human Factors doctoral program and Dunne in Electrical and Computer Engineering

offering opportunities to link research in the Center with related graduate programs. The HDL has experimented with teaching methods that have potential of changing apparel design and technology education. Technologies in the HDL have been used to teach undergraduate apparel design students about designing for real body shapes and sizes and for considering designing for the body using 3-dimensional modeling. We believe that our undergraduate students are the only U.S. apparel design students using digital draping on 3-D scanned bodies to learn principals of apparel design. Technologies and techniques from the WTL have been used to teach undergraduate apparel students about emerging technologies for functional apparel such as active light and heat sources. We also believe that our undergraduate students are the only US students currently using electronic technologies to achieve functional apparel objectives. The umbrella structure for the separate labs and studios will provide opportunities to develop multi-disciplinary teams addressing a range of problems. The Center will provide incentives to develop new teaching and learning strategies that will expand the definition of apparel design.

Research

Researchers at the University of Minnesota are recognized as leaders in apparel fit and sizing with research initiated almost 30 years ago. Researchers have developed theory and methods to improve technologies. Collaboration with University of Minnesota partners from other units (mechanical engineering, electrical engineering, computer science, psychology, physiology, psychiatry, medicine and more) is a typical working mode to develop projects that have real world applications. Researchers have a working relationship and common research interests with researchers in the Center for Design and Health. Researchers also work with industry (Optitex, Target, Nike, and more) to remain relevant in producing research results. The HDL researchers also work with the Cornell University Body Scan Research Group, sharing data, results, and expertise to advance knowledge. The NC 170 multi-state research project that is carried on with researchers throughout the USA is an excellent collaboration that will result in improved protective gear for first responders.

Outreach

Researchers currently participate in many outreach endeavors and have an established track-record with the Minnesota Extension Service coordinating research and outreach programming through outstate educators. A successful, multi-phase, multi-year project, SunSmart, is an example of an award winning research to outreach program that has educated well over 20,000 children and adults throughout the state of Minnesota on the importance of and method of ensuring sun safety. Center researchers have also developed pesticide safety programming for Minnesota pesticide applicators as part of the FDA-sponsored Multi-State Research Project, NC-170. This project demonstrates the potential of linking all Center units with elements of new designs for pesticide protection incorporating fit and motion, technology, innovative textiles and apparel structures, and perceptions of the user. Other outreach efforts currently under

development include a collaboration with the Bakken Museum of Electricity to teach about sew-able electronic textiles to girl scouts and high school students.

International outreach opportunities occur with various cultural exchanges with South Korea and now one being planned with China's, Donghua University. These programs are mutually beneficial to our Asian counterparts as well as our own undergraduate and graduate students. Other outreach opportunities for the Center are possible through the publication, *Fashion Practice, Journal of Design, Creative Process and the Fashion Industry*. This is a journal, international in scope that offers a link to international outreach and strives to bring together cutting edge research from around the world.

Competition

The four researchers proposing the lab are well-connected to apparel and wearable products researchers around the world. To our knowledge there is no research facility comparable to the proposed center with the combination of research backgrounds, knowledge of design (particularly apparel), and location within a major research university. Other research facilities with related research agendas include:

- Carnegie Mellon, Wearable Computing: researchers do not have background in apparel design, but rather focus on the ultra-mobile computer or personal device interface.
- MIT Media Lab, Hi-Lo Tech Group: research includes sew-able electronics used in wearable technologies, but the main focus is on craft technology in general, not specifically on wearables.
- University of Wales, Newport, Smart Clothes and Wearable Technology program, Director Jane McCann: not an integrated research lab, no teaching function or anthropometric focus.
- Virginia E-Textiles Lab: focus on electronic textiles, apparel is a peripheral interest.
- Cornell University Body Scan Research Group: Director Dr. Susan Ashdown (doctoral degree, apparel studies, University of Minnesota): focus on body scan technology, UMN researchers collaborate with Ashdown on several projects

Timeline:

Year 1:

- Create and establish identity
- Explore collaborative project and funding opportunities
- Develop strategies to attract graduate students

- Apply for grants to fund projects

Year 2:

- Recruit graduate students
- Continue to write grant proposals
- Initiate collaborative research/outreach projects

Year 3:

- Continue to develop research projects/write grant proposals
- Disseminate research results through appropriate conferences/journals
- Recruit graduate students

Evaluate research programs, goals, reposition if necessary

Year 4:

- Evaluate viability of the Center with assistance of College of Design deans and DHA department head to determine future goals or plan for phase-out over the next two years.

Resource Requirements:

Current facilities, faculty, staff, and graduate students are sufficient to continue established research agendas, however, we believe that establishing a named Center will greatly improve funding opportunities and success rates.

Lab/studio locations are established including:

Human Dimensioning© Lab: Was established with NSF funds to house a full body scanner, dressing rooms for use by subjects, prototype production equipment, computers used to manipulate scan data, and meeting space.

Wearable Technology Lab: Remodeled with CDes funds to accommodate two motion capture systems, a Cyberquins Running Mannequin, electronic circuit design and prototyping equipment, and a biological data acquisition system. The Wearable Technology Lab also houses an extensive range of textile testing equipment (acquired with the HDL NSF grant) including an Instron tensile tester, a Taber Abraser, and a fume hood.

Experiential Lab: Space to organize projects and receive participants and collaborators working on preferences, knowledge, and experience related to wearable products.

Wearable Innovation Studio: The spaces for this studio are dual use, and include adaptable space in the HDL with prototype production equipment and space for ideation and collaboration; and space in 336 for materials testing.

Marketing Plan:

Center researchers will work with the College of Design to establish an identity and to develop a web page that will be a sub-category of the College of Design web site. The current HDL web site will be incorporated into the new center web site. The new URL will be featured on all researchers' business cards and electronic communications.

Announcements about the new center will be incorporated into any new editions of the apparel design newsletter. We will also work with University news service to promote the center and its research and teaching capabilities. Graduate students will be recruited with fliers distributed at professional conferences.

Advisory Board:

The advisory board for the Center will be formed from reviewers for the proposal and from members of the current Apparel Design Advisory Board (See Appendix B).

Budget:

The proposed Center is different from other CDes Centers, as all research personnel are full-time tenured/tenure track faculty. Their salaries do not rely on soft monies, so their salaries are not included as part of this budget. Each researcher currently has a research assistant funded with AES monies. Additional research assistants have been funded through grant monies.

Current known recurring costs of operating the HDL and the WTL include:

Annual maintenance agreements for hardware and annual license fees for software have been paid with some base DHA funding and with portions of grant awards. Each grant award includes an amount of funding for these recurring costs. Researchers in the Center will collaborate on strategies to plan ahead in funding these recurring costs.

Human Dimensioning© Lab current costs:

Annual hardware and software warranties & licenses: \$30,000
(currently from grant monies)

Wearable Technology Lab current costs:

Upkeep, repairs, replacement parts \$10,000

Sources of Funding:

The Human Dimensioning© Lab and the Wearable Technology Lab have been funded with some department funds and with grant monies, both internal and external. Researchers realize that external grant funding will be essential in maintaining the labs and studios. The formal establishment and naming of this Center will provide enhanced opportunities for grant acquisition from outside funding agencies such as NSF, NIH, foundations, and industry. The Center research coordinators will seek funding that includes ICR and that will fund on-going technology fees, additional research assistants, and a part-time Center administrative assistant. An advantage of having 4 full-time faculty as the core researchers for the Center is the ability to use faculty salaries as a “match” for grants thus increasing total dollar amounts.

Evaluation Benchmarks:

1. Center personnel will evaluate its goal achievements by:
 - Continuing to obtain funding from current funding sources
 - Obtaining funding from additional sources
 - Continuing to present findings at national and international conferences
 - Having papers accepted for publication in refereed journals as well as providing opportunities for other research to be published in journals edited by Center researchers
 - Expanding influence in new methods in apparel design/production/and use
2. The Center will be evaluated according to successes in attracting funding. Evaluation will be conducted with feedback from the College via the Associate Dean for Research and Outreach.
3. We do not see that the Center will become obsolete anytime in the near future. The current independent research areas are leading research efforts in fit and sizing, wearable technology and new and innovative approaches to apparel design education and practice.

Exit Strategy:

The Center will be evaluated annually with an assessment of viability occurring at year 4 after the Center is officially established. The Center will be reviewed by the College of Design deans and the DHA department head. If the Center is not meeting its major objective of increased grant funding (especially external grant funding) the Center will be dissolved over the following 2 years.