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A Study on Integrating Futures Thinking into the User Experience Design Process for Wearable Technology[1)]

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ABSTRACT

The impact of wearable technology on our lives has significantly expanded during the COVID-19 pandemic, highlighting its importance as an area for future development. This study proposes an improved design methodology for developing wearable technology that is more convenient, useful, creative, and innovative from the user's perspective. First, it analyzes the development trajectory of wearable technology, identifying the increasing importance of fashion and the need for an enhanced UX (user experience) design. It also emphasizes the application of Futures Thinking to foster more creative and innovative ideas. Second, it compares different approaches to fashion, design, and technology in the context of wearable technology. By merging elements from these fields, a new design methodology is proposed. Third, a wearable technology design workshop was designed and conducted to apply and refine the proposed methodology. The results of this study are presented as a comprehensive methodology for designing wearable technologies. This approach underscores the crucial role of design in technology-related convergence fields and has significant social and practical implications for both academic research and the industrial sector.

KEYWORD

Design Methodology, Wearable Technology, Fashioning Technology, Futures Thinking, User Experience Design, Interdisciplinary Approach

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1. Introduction

1.1. Research Background and Purpose

The consumer market for wearables has grown rapidly as health concerns have increased during the coronavirus pandemic. Four categories of wearables are already deeply embedded in consumers' lives: sports and fitness trackers, health and medical devices, smartwatches, and smart glasses (Levin, 2014). Wearables interconnect multiple devices to smartphones that people already own, and provide a range of services. Online and offline ecosystems centered on wearables are expected to become even more powerful in the future as wearable technology becomes increasingly integrated into people's lives, offering new services that will have a tremendous impact on their daily routines.

The leap in wearable technology has been driven by exploratory research into the close interactions between electronic devices and humans; this research has surged in recent years. However, while the wearable market is expanding, it is limited to non-textile products, such as smartwatches and smart glasses, which limits its expansion into the fashion market. To overcome this, e-textiles—composed of electronic components and fibers—are attracting attention as new alternatives to conventional heavy, rigid, and difficult-to-wear devices, because they are lightweight, flexible, and breathable. Consequently, fashion technology developed using e-textiles is emerging as a promising field. For wearables to develop into a market that will expand into everyday life, such as fashion, it is essential to develop wearable technology products by applying fashion technology to e-textiles. Therefore, various experiments incorporating technology into e-textiles are being conducted, and these are now being developed for commercialization (Seyedin et al., 2021).

To accelerate the acceptance and commercialization of fashion technology products, it is necessary to satisfy user needs from a fashion perspective, create new user experiences from a design perspective, and provide convenience from a technological perspective. In particular, future-oriented innovative products and new user experience (UX) services that go beyond the existing fashion consumption needs and functions of the underlying technology can create a new market for fashion wearable technology. Therefore, this study aims to examine design

methodology to discover innovative products and services for wearable technology. To this end, this study examines the application of future thinking based on the UX design process.

In this study, the scope of wearable technology is defined as fashion wearable technology that comes into contact with the body, excluding smart watches, VR devices, and headsets, which occupy a significant portion of the wearable market. This study focuses on wearables that can be seamlessly integrated into daily life, particularly those that can be enhanced through the convergence of fashion and technology. This study aims to provide a clear and specific analysis of the development process and user-experience design of wearable technology that is closely related to fashion and everyday utility, narrowing the scope to fashionable wearable technology, rather than wearable devices centered on hard hardware, which currently hinders market expansion.

The Futures Thinking methodology was chosen for this study because it allows for the anticipation of long-term trends and the envisioning of multiple future scenarios. This approach helps generate creative and adaptable ideas that can meet evolving user needs. By applying Futures Thinking, this study leverages a forward-looking perspective that encourages innovative solutions beyond immediate technological constraints. In addition, this study aims to apply design methodology to the convergence of fashion and technology development processes utilizing e-textile kits, thereby connecting wearable technology with fashion to foster further creative development.

1.2. Research Methodology

This study was conducted in the following order. First, the current limitations of wearable technology and the requirements for its development were analyzed from a design development perspective. Second, fashion design and technology approaches for the development of wearable technology were compared, and a new design methodology that merges some of their elements was derived and proposed. Third, a wearable technology design workshop was conducted using the proposed design methodology, and the workshop results were analyzed to confirm the effectiveness of the proposed design methodology and to propose specific measures for its further refinement.

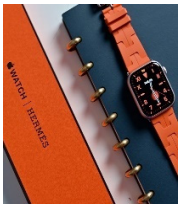
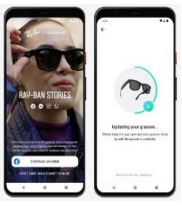
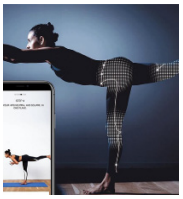
2. Analysis of Wearable Technology Trends

2.1. Integration of Fashion and Technology in Wearables

Fashion—the accessories, clothing, and other items worn on the body—expresses the self and serves as an essential vehicle for personal identity and personality. As devices worn on the body, wearables provide a balance between function, interaction with each other, and fashion. Therefore, in addition to choosing a technological advantage, users consider fashion an essential factor when choosing a wearable device. Wearable technology is still in the early stages of the mass market because it has yet to meet the public's fashion expectations. In addition to the technical development of wearable technology devices, it is necessary to improve their functionality and interactive design to a level that meets the public's fashion expectations. In recent years, products that fulfill fashion desires beyond functionality have emerged, creating a new market for wearable technology.

An example is the Apple Watch Hermès, a smartwatch collaboration with a luxury brand that launched in 2019 and continues expanding its market. Other fashion accessories that function as wearable technology include Oura Ring, a smart ring for exercise, stress, and sleep, and Ray-Ban's collaboration with Meta, a pair of sunglasses that facilitate social networking services. The Levi's Commuter project—a collaboration between Google's Jacquard project and Levi's—and Wearable X's Nadi X Yoga Pants are examples of apparel integration. Table 1 analyzes each of these examples in terms of their function and role in fashion (Bohannon, 2024).

Table 1 Comparative Analysis of Wearable Technology that Functions as a Fashion

Feature/ Aspect	Apple Watch Hermès	Oura Ring	Meta Ray-Ban Stories	Levi's Commuter Trucker Jacket	Nadi X Yoga Pants by Wearable X
Primary Functionality					
Primary Functionality	Smartwatch Features (Notifications, Apps)	Health Monitoring (Sleep, Heart Rate)	Smart Glasses (Photo/Video, Music)	Interactive Jacket (Smartphone Control)	Yoga Assistance (Haptic Feedback)

Feature/ Aspect	Apple Watch Hermès	Oura Ring	Meta Ray-Ban Stories	Levi's Commuter Trucker Jacket	Nadi X Yoga Pants by Wearable X
Fashion Element	Hermès Design, Luxury Leather bands	Sleek, Minimalist Jewelry Design	Iconic Ray-Ban Styles	Classic Levi's Denim Jacket	Stylish, Form-Fitting Yoga Wear
Key Technological Features	Custom Watch Faces, Fitness Tracking	Sleep Tracking, Heart Rate Monitoring	Built-In Cameras, Speakers, Microphones	Touch-Sensitive Fibers in Cuff	Embedded Haptic Sensors
Customization Options	Multiple Band Styles and Colors	Various Finishes (Silver, Black, Gold)	Frame Colors, Lens Options	Traditional Denim with Smart Cuff	Different Colors and Patterns
Integration with Ecosystem	Seamless with Apple Ecosystem	Oura Mobile App for Health Insights	Meta View App for Content Management	Google Jacquard App for Gesture Control	Wearable X App for Guided Sessions
User Experience Interaction	- Intuitive Touch Screen, Haptic Feedback, Voice Control - Health and Fitness Tracking with Detailed Analytics in the Apple Health App - Notification Alerts, Customizable Watch Faces	- Simple, Intuitive Interface via Mobile App - Detailed Health Insights and Trends - Automatic Sleep Detection and Readiness Scores - Gentle vibration Alerts for Inactivity	- Voice Control via Built-in Microphones - Touch Interface for Easy Navigation - Hands-Free Photo and Video Capture - Notifications and Audio Streaming Directly Through Glasses	- Gesture-Based Interactions via Touch-Sensitive Cuff - Integrated with Smartphone for Music Cand Navigation - Automatic Activity Detection - Real-time Feedback Through Subtle Vibrations	- Real-Time Feedback through Haptic Sensors - Guided Yoga Sessions via the Wearable X App - Vibrations Indicate Proper Pose and Alignment - Integration with Fitness Apps for Tracking Progress

Through a comparative analysis, it was found that wearable technology must be developed to the same level as currently worn fashion accessories and textile clothing for public demand to be formed. Therefore, when developing wearable technology products, it is necessary to develop products that can satisfy consumers' desires for existing fashion beyond the incorporation of technology. Therefore, it is necessary to design wearables considering how people feel when wearing them, how they look, and how they are perceived by others.

2.2. The Role of UX Design in Wearable Technology

Researchers and developers often focus on their areas of expertise, emphasizing technical achievements and specific functional goals. This can lead to products that excel technologically, but fall short in terms of practical and everyday usability. The development process typically involves evaluating the success or failure of technical aspects, rather than the overall UX. This

can result in devices that meet technical standards but fail to effectively address user needs and preferences. By focusing on the end product and how it fits into users' lives, UX design helps bridge the gap between technical functionality and practical usability, thereby increasing the likelihood of commercial success. Wearable technology products that are primarily function-driven often neglect crucial UX factors, such as interaction design, usability, and user interface. These factors are critical to user acceptance and satisfaction. Users are unlikely to adopt or continue using wearables that are difficult to interact with, uncomfortable, or aesthetically unappealing.

Wearable technology has the unique potential to influence how users are perceived by others, how they interact socially, and how they manage their physical spaces (Dunne, 2024). This adds a layer of complexity beyond technical functionality. The field's novelty is that traditional methodologies from electrical engineering and computer science may not adequately address the social, psychological, and physical dimensions of user interaction with wearable devices. UX design and methodologies specific to wearable technology are relatively unexplored. Researchers in technical fields may not be accustomed to considering variables related to physical comfort, social acceptance, and mental interactions. Successful wearable technology design requires an interdisciplinary approach that combines technical expertise with insights from design, psychology, ergonomics, and social sciences.

To effectively advance wearable technology, it is crucial to incorporate UX design from the development stage. This ensures that the technology is not only technically sound, but also user-centric, addressing the full spectrum of user needs and preferences. By adapting the UX design's holistic view, wearable technology can achieve higher rates of commercialization and user acceptance, ultimately fulfilling its potential to enhance daily life and social interactions.

The Levi's Commuter Trucker Jacket is a prime example of how integrating UX design can enhance wearable technology (IDEO, 2024). Initially, the focus was on embedding advanced technology into the fabric to create a functional garment that could interact with smartphones. However, early iterations of the jacket faced challenges in terms of user interaction and practical usability.

Recognizing the need for a more user-centered approach, the development team conducted extensive user research, including field studies and contextual inquiries, to understand

how cyclists and commuters would use the jacket in real-world scenarios. This research highlighted the importance of intuitive interactions, comfort, and the aesthetic appeal of the jacket. Based on these insights, the team made several key design changes. They simplified the interaction design, allowing users to control their smartphones with simple gestures on the jacket's sleeve, enabled by touch-sensitive Jacquard threads. The team also focused on the jacket's comfort and durability to ensure that it met the requirements of daily commuters. Additionally, the design incorporated Levi's classic denim style, making it fashionable and appealing to a broad audience.

Integrating UX design not only improved the functionality of the jacket but also enhanced its UX. The jacket allowed users to easily control music, receive navigation prompts, and handle calls without needing to touch their smartphone, all while maintaining the look and feel of a traditional denim jacket. This seamless blend of fashion and technology resulted in a product that was both practical and stylish. By prioritizing UX, the Levi's Commuter Trucker Jacket achieved greater user satisfaction and adoption. This case study underscores the importance of incorporating UX design into the development of wearable technology to ensure that products are not only technically advanced but also user-friendly and aesthetically pleasing.

The development of the Levi's Commuter Trucker Jacket by Google Jacquard illustrates the critical role of UX design in wearable technology. By focusing on user needs, social context, and fashion elements, wearable devices can achieve higher levels of market penetration and user acceptance, ultimately enhancing daily life and social interactions.

2.3. Envisioning a Future Beyond UX Design

The future of wearable technology depends on its mass market acceptance and penetration into larger markets. For wearable technology usage to grow, wearable technology devices must be able to fulfill users' physical, cognitive, and social needs and move beyond functionality or traditional fashion to create new experiences and social and cultural impacts. William Ford Gibson once said, "The future has already arrived. It's just not evenly distributed yet." The technology already exists, but it needs to be embraced by users, with the use of creative and innovative products and services. Rather than focusing on current problems, creating

something new for the future is crucial.

A design methodology that reflects this has been actively proposed in recent years, evolving from design fiction and speculative design, to Futures Thinking (Roumiantseva, 2024). Table 2 presents a comparative analysis of these three new methodologies. Design fiction uses storytelling and prototyping to explore and provoke discussions about future technology and its societal implications. Speculative design explores possible futures by creating tangible artifacts and scenarios that challenge assumptions and explore alternative realities. Futures Thinking involves systematically exploring, forecasting, and planning for future scenarios to inform strategic decision-making and innovation.

Table 2 Comparison of Future-reflective Design Methodologies

Feature	Design Fiction	Speculative Design	Futures Thinking
Focus	Using Fictional Narratives to Explore Future Consequences	Using Design Artifacts to Explore Future Impacts	Exploring a Range of Future Possibilities
Process	Research, Creating Fictional Narratives	Research, Prototyping, Creating Thought-Provoking Artifacts	Scenario Planning, Horizon Scanning, Backcasting
Deliverables	Stories, Films, Video Games, Interactive Websites	Physical Prototypes, Installations	Reports, Presentations, Workshops

Given the limited commercialization of wearable technology products and services, combining idea generation for current problems with Futures Thinking is crucial to explore and imagine 10-15 years ahead. This approach will likely create a market for creative and innovative ideas in the wearable technology space. Futures Thinking provides a structured and comprehensive methodology that combines foresight, strategic planning, and creative exploration. Figure 1 shows how ideas are expanded through the Futures Thinking process. It is particularly suited for wearable technology development, as it prepares designers to holistically address future challenges and opportunities, fostering innovation that is both forward-thinking and practical. This ensures that new products are technologically advanced and socially and culturally relevant in the long term.

The process outlined in "Exploring Features of the Design on Futures Thinking" by Xia and Fu (2021) involves participants role-playing, encouraging them to embody different future

scenarios. This approach allows participants to explore and experience potential futures, providing insights into how various trends and features may interact. This method helps generate innovative ideas and understand the broader implications of future trends and technology.

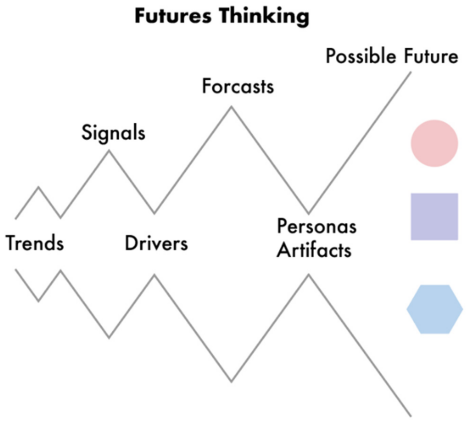


Figure 1 Futures Thinking

Participants in a futuristic design development process may start indifferent; however, as the process progresses and they engage in role-playing and future scenario design, they become more invested and active in development. This exploration can lead to a social and cultural perspective on the design basis by asking participants to construct future scenarios together. Futures Thinking uses time to enrich the exploration of methods, content, and boundaries of design based on future development trends. Under these conditions, it focuses on exploring the characteristic analysis of design to identify the creative and innovative technology that can be used in the future (Xia & Fu, 2021).

Often, Futures Thinking is limited to proposing scenarios; however, by integrating it into the UX design process, concrete design outputs can be presented by connecting it to prototyping. Incorporating Futures Thinking into UX design allows the proposal of a new type of design with a visual, tactile, and intuitive vocabulary for the wearable technology envisioned in future scenarios.

3. Proposed Design Methodology for Wearable Technology

3.1. Developing a Creative Design Approach

The evolution of wearable technology requires an increased role for fashion, an emphasis on UX design, and creative and innovative ideas for future uses. To develop wearable technology in this evolutionary direction, it is necessary to understand the approach of three disciplines: technology, fashion, and design.

First, we need to understand how technology researchers and developers create wearable technology products and services that people can easily accept and adapt to their lives. Currently, researchers and engineers have been at the forefront of wearable technology advancements, but this has resulted in a lack of attention to aesthetic details in the development process, such as form, line, and texture, which can make a product more desirable to customers.

Secondly, we need to consider why wearable technology has not yet been fully embraced by the fashion sector. Involving fashion designers and apparel experts in the development of wearable technology can help fill the gaps in the technology development-centered process. These experts provide insight into the identity and culture of the customer, making the product more accessible and adaptable. The fashion sector relies heavily on trend research and comprehensive data on target markets and consumers. This data captures the perspectives of socially and lifestyle-influenced consumer groups, allowing fashion designers to connect with their customers' identities and lifestyles to create creative fashion designs.

The third perspective is UX design, where the rapid growth of wearable technology has led to an increased understanding of product and human-computer interaction. Wearable technology enables users to interact with devices and products daily, solving their needs and connecting to the internet to exchange information and develop relationships. Considering how people interact and build relationships with wearable technology products and services is critical to their development. Haptic feedback and high visual and operational clarity facilitate the connection between user and device, accelerating the phenomenon of users becoming more dependent on wearable technology. Users now expect technology to deliver multiple services more efficiently or enhance their experience, leading them to constantly demand newer and more advanced wearable technology products and services (Wallace, 2014).

This approach to fashion, design, and technology influences the development process of wearable technology. By analyzing the advantages and disadvantages of the development stages of each of these three fields, we can derive a comprehensive design process for wearable technology. This tri-disciplinary methodology ensures that wearable technology evolves in a direction that is technologically advanced, socially relevant, and culturally resonant.

3.2. Integrating Fashion, Design, and Technology

This study aims to develop creative and innovative products and services in the field of wearable technology by using the 'Futures Thinking' methodology to generate ideas and refine them through prototyping of UX design. In order to present a specific design methodology, the research compares and analyzes the design development methodologies of three fields related to wearable technology: fashion, design, and technology (Lee, 2017). By doing so, Figure 2 shows that the research combines some of the processes from each field to further refine the proposed methodology.

A schematic representation of the three disciplines is shown below. The fashion approach consists of research on trends, markets, and consumers, followed by concept sketching and prototyping from an apparel design perspective. In the UX design process, research on users and their inspiration is followed by ideation and prototyping, while in the technology field, it is technology-driven prototyping and development.

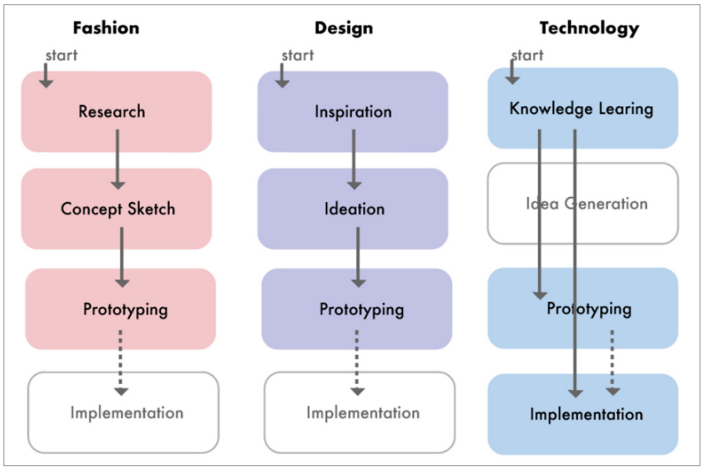


Figure 2 Comparing Methodologies across Fashion, Design, and Technology

In this study, a methodology of Figure 3 is proposed to develop creative and innovative wearable technology products and services by integrating elements from UX design, fashion, and technology. The process begins by combining user experience research with market and trend research from the fashion field to organize various inspirations and generate ideas through brainstorming. Selected ideas are then developed into scenarios using personas and 'Futures Thinking', with role-playing to maintain a futuristic perspective and materialize ideas. Participants will use e-Textile Kits to learn basic fashion design and wearable technology development, enabling practical prototyping. This approach ensures that the resulting products are innovative, user-centric, and aligned with future trends.

Wearable technology should leverage both its technological features and its value as fashion, integrating fashion design's insights and aesthetics. Designing e-textiles requires careful consideration of the number, dimensions, and placement of electrodes or devices to achieve targeted functions. Without understanding wearable technology, fashion design and user interaction design can face challenges. Knowledge of different sensors, output devices, and smart fiber materials enhances the scope of imagination in wearable technology. Thus, proficiency in UX design, fashion design, and wearable technology prototyping is crucial for developing innovative products.

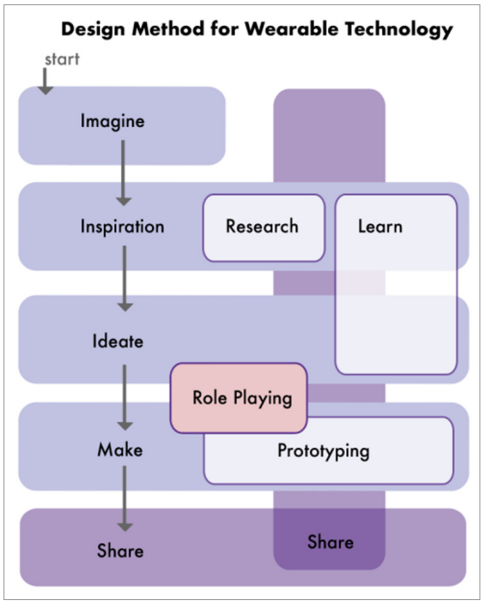


Figure 3 Design Methodology for Wearable Technology

4. Implementation of the Design Methodology

4.1. Workshop Planning and Execution

In order to validate and further develop the proposed design methodology for wearable technology, a workshop was conducted focusing on 'Futures Thinking' and the UX design process (Lee et al., 2023). The workshop aimed to create a prototype that integrates the design and technical characteristics of wearable technology. The following criteria in Table 3 were prioritized to maximize creative and innovative idea generation:

Table 3 Workshop Criteria for Developing Wearable Technology

Criteria	Description
Team-Centered Development	Emphasized collaboration and sharing to foster creative ideas and their implementation.
Technological Understanding	Ideas were generated with a solid understanding of the underlying wearable technology.
User Needs and Future Experiences	Prioritized user needs and envisioned future experiences to ensure technology did not constrain creativity.
Prototyping and Role-Playing	Maintained creativity through role-playing and prototyping, focusing on future scenarios rather than immediate technical feasibility.

The workshop is designed to follow the user experience design process, enabling participants to engage in a forward-thinking design process while simultaneously acquiring knowledge of the technologies used in fashion design and wearable technology using the e-Textile Kit, which consists of Circuit Playground Express(Adafruit.com) and MakeCode(MakeCode.org) programming.

In the Inspiration phase, two subfields, Research and Learn, are conducted simultaneously. In Research, participants engage in UX design research methods, including field research, contextual inquiries, surveys, literature reviews, and expert interviews. Additionally, they conduct fashion research on trends, target markets, and consumer behaviors. The insights gathered are organized using an Affinity Diagram. In the Learn subfield, participants use e-Textile Kits to gain practical experience with wearable technology, learning about hardware and programming alongside their research.

The Ideate phase builds on the insights gained from the Inspiration phase to formulate "How Might We?" (HMW) questions, a method derived from IDEO.org's Design Kit, which guide brainstorming sessions for developing creative ideas. These ideas are then evaluated and selected based on criteria such as innovation, creativity, and feasibility. The chosen ideas undergo a Gut Check from IDEO.org's Design Kit to refine them, ensuring that all team members have a clear and concrete understanding. Personas and scenarios are developed to visualize how users will experience the ideas, and participants explore open-source resources to enhance their designs.

During the Make phase, participants create low-fidelity prototypes using simple materials and role-play scenarios to define specific features and interactions. These prototypes are then developed into partial prototypes incorporating technology and fashion elements using e-Textile Kits and fabrics. Usability tests are conducted to gather feedback, and the prototypes are refined into high-fidelity versions based on the results (Lim, 2021).

In the Share phase, the entire design and development process is meticulously documented and shared within the open-source ecosystem. This includes creating videos and detailed documentation to predict outcomes and detail specific development steps. Sharing these resources facilitates the possibility of further developing the prototypes into real services through crowdfunding and collaborative efforts. This comprehensive methodology ensures that the development of wearable technology is innovative, user-centered, and aligned with future trends and user needs.

4.2. Modification and Re-Running Workshops

Between January and February 2022, 26 university students from various majors teamed up to participate in an eight-week wearable technology design workshop that culminated in five final projects. The university students who participated in the study were three sophomores, 11 juniors, and 12 seniors. In total, 26 students participated in the curriculum activities in this study. Therefore, the final number of participants who completed all the curriculum activities was 16, including 8 juniors and 8 seniors. The majors of the final study participants were social sciences, science and engineering, arts, education, and life sciences (Lee et al., 2023).

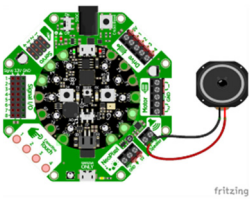
Based on the results of this workshop, the design process was reinforced, and a workshop with an enhanced design methodology was conducted in the first semester of 2023 with university students working in five teams. A total of 25 students participated in the workshop, mostly visual design majors, but also computer science and advertising majors.

In the first workshop, the "Ideation" phase, with its How Might We? questions and brainstorming methods, focused on imagining what would happen in the real world, was deemed to be limiting in terms of imagining ideas more freely. Therefore, in the second workshop, the ideation phase was changed to include role-playing of future scenarios from Futures Thinking to allow for more freedom of imagination in the enhanced user experience process.

1. Future Scenario Development: Create detailed scenarios of future contexts where wearable technology might be used. This involves identifying potential future trends, user behaviors, and technological advancements. By envisioning these scenarios, participants can understand the broader context in which their ideas will operate.
2. Role-Playing Exercises: Participants engage in role-playing to immerse themselves in these future scenarios. This allows them to experience and interact with the imagined future technologies, providing deeper insights into how users might engage with their ideas in real-world contexts.
3. Idea Generation Workshops and Selection: Hold workshops where participants brainstorm ideas based on future scenarios. Encourage creativity and out-of-the-box thinking to develop innovative solutions. This step focuses on generating a wide range of ideas without immediate concern for feasibility. Introduce a structured idea selection process where participants evaluate and choose the most promising ideas based on criteria such as innovation, feasibility, and user impact. This ensures that the best ideas are chosen for further development.
4. Idea Persona and Scenario Design: Develop specific personas and scenarios for the selected ideas. This involves detailing how different types of users might interact with the wearable technology in various contexts, refining the concepts to ensure they are user-centric and aligned with future trends.

The following is how the idea for the ASMR Sleep Hoodie that helps sleep was generated. Table 4 shows how the idea evolved step by step in the second workshop.

Table 4 ASMR Sleep Hoodie

Role-Playing	Concept Image	Low-Fi Prototype	Mid-Fi Prototype
			

In developing the 'ASMR Sleep Hoodie', a team of five students from different disciplines collaborated to address user requirements. They identified key needs through extensive research into sleep disorders, focusing on comfort, relaxation aids, and seamless integration of technology.

Fashion research involved analyzing trends in sleepwear and consumer preferences for comfortable, hygienic materials. The students ensured the hoodie was aesthetically pleasing and functional. One of the students contributed insights into the calming effects of ASMR and how it could be effectively integrated into sleepwear.

Using this data, the team conducted role-playing exercises to develop personas and scenarios. They imagined a 20-year-old female with sleep disorders who uses ASMR for relaxation. The team visualized these scenarios, ensuring the product met the user's needs in various contexts.

For prototyping, the students collaborated to embed small speakers in the hood for ASMR playback and sensors to monitor heart rate and temperature using the e-textile kits. The team ensured the placement of these components maintained comfort and usability. The team created low-fidelity prototypes to test these features, gathering user feedback to refine the design.

The final prototype was tested for usability and comfort, with the team conducting user tests to gather data on the ASMR experience and overall comfort. They analyzed this feedback, leading to further refinements. The entire process was documented and shared on collaborative platforms for continuous improvement based on user interaction and needs. This interdisciplinary approach ensured the ASMR Sleep Hoodie was both innovative and user-centered.

A second workshop with a modified idea generation process resulted in the following enhanced process steps. Adding future scenario development to set the stage for the entire process by providing a clear vision and imagining of potential future situations. Helping participants to look beyond current limitations and consider how the emerging trends they investigated in the "Inspiration" phase will impact user behavior and needs. The added role-playing immerses participants in future scenarios, allowing them to empathize with future users. This method can provide valuable insights into user interactions, potential pain points, and overall user experience, making your ideas more robust and user-centered.

4.3. Design Methodology Refinement and Validation

Two workshops evolved a design methodology for wearable technology. The idea generation phase of the first workshop, based on the user experience design process, was refined by applying the Futures Thinking phase. The finalized design methodology for wearable technology is shown in Table 5.

Table 5 Proposed Four-Step Design Methodology Workshop for Wearable Technology

Phase	Detailed Steps	Activities
Inspiration	1. Background Research	Conduct background research on user needs and desires.
	2. Fashion Market Research	Analyze current fashion market trends and innovations.
	3. Trend and Innovation Research	Research trends and innovations in wearable technology.
	4. Organize Insights	Synthesize research findings into actionable insights.
Ideation	1. Future Scenario Development	Create detailed scenarios of future contexts where wearable technology might be used.
	2. Role-Playing	Participants immerse themselves in future scenarios. Experience and interact with imagined future technologies to gain deeper insights into user engagement.
	3. Brainstorming & Idea Selection	Brainstorm a wide range of ideas on the future use of wearable technology. Evaluate and choose the most promising ideas.
	4. Idea Personas & Scenarios Design	Detail how different types of users might interact with the wearable technology. Refine concepts to ensure they are user-centric and aligned with future trends.
Prototyping	1. Low-Fidelity Prototypes	Create low-fidelity prototypes and role-play scenarios to explore user, context, and technology interactions.
	2. Acquisition and Understanding of Basic Electronic Engineering Knowledge	Learn to use e-Textile kits, including Circuit Playground Express and MakeCode programming.

Phase	Detailed Steps	Activities
	3. Develop Working Prototypes	Build working prototypes using e-Textile kits.
	4. Usability Testing	Test prototypes for usability and refine designs based on feedback.
Sharing	1. Finalize Concepts	Finalize product and service concepts based on testing results.
	2. Document Process	Document the entire process, including research, ideation, prototyping, and testing.
	3. Open Source Collaboration	Share documentation and prototypes on Google Sites and GitHub.
	4. Interactive Critiques and Presentations	Present prototypes to peers and mentors for feedback and engage in interactive critiques.

To validate this design methodology, a Delphi survey was conducted to gather expert opinions and assess its validity and potential areas for improvement. Ten experts participated in the survey, including two fashion experts, three physical computing experts, and five user experience design experts. Initially, an open-ended survey was conducted to collect the experts' opinions on the primary design methodology. The results of this survey were then analyzed using frequency analysis and content analysis to identify core opinions. In the second round, the summarized results were presented to the experts, and a follow-up survey was conducted to seek their agreement and gather supplementary opinions. The final step involved comparing the results of the first and second surveys to identify changes in opinions and areas of agreement.

The results of the Delphi survey indicate a positive evaluation of the design methodology for wearable technology. Firstly, it resulted in innovative and creative design methodologies. Experts agreed that the forward-thinking design approach is innovative and creative compared to traditional methodologies. The user-centered design approach, involvement of experts from various disciplines, and creation of future scenarios were highly valued. Secondly, the methodology is expected to contribute significantly to the advancement of wearable technology. Experts believe that it can improve the functionality, design, and user experience of wearable technology. Innovative features such as personalized ASMR, augmented reality, and smart fabrics are seen as valuable in shaping the future direction of wearable technology. Thirdly, the design methodology was evaluated as practical and applicable. Experts anticipate that the

systematic design process, which includes user research, market and trend analysis, and prototyping, will be highly practical for actual product development.

However, the experts suggested several improvement directions for the design methodology. Firstly, the participation of experts in validating the methodology should be expanded. Including experts from a broader range of fields, such as social sciences, humanities, and medicine, can increase the validity of the design methodology. Secondly, projects that apply the studied design methodology should be presented as ongoing examples. Showcasing successful examples of wearable technology products or services developed using the methodology will help continuously refine and improve it.

5. Conclusion

Through this study, a hybrid methodology that fuses the fields of fashion, design, and technology for wearable technology is proposed. A workshop was conducted to demonstrate how design methodology can overcome the limitations of wearable technology development, resulting in a methodology that combines user experience-centered design with 'Futures Thinking', enabling prototype development using wearable kits. This methodology offers a starting point for the creative development of future wearable technology. However, the study is limited by its qualitative nature and the small participant group, necessitating follow-up studies to reinforce the findings.

Key contributions of this study include emphasizing the importance of integrating science and design for creativity, proposing a new design methodology for wearable technology that addresses the entire user experience, and generating knowledge and original concepts related to fashion design and science. This methodology will aid in training professionals in academia and strengthen development methodologies used in fashion technology companies. For wearable technology to create real opportunities for the future of fashion, efforts must be made to reorganize development methodologies and models integrated with specialized areas. This study aims to initiate deeper discussions among professionals, developers, and educators in various fields related to wearable technology.

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웨어러블 테크놀로지를 위한 사용자 경험 디자인 프로세스와 미래적 사고 융합 연구

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초록

웨어러블 테크놀로지가 우리 생활에 미치는 영향은 코로나19 팬데믹 기간 동안 크게 증폭되었으며, 미래 발전 분야로서 그 중요성이 부각되고 있다. 본 연구는 사용자 관점에서 보다 편리하고 유용하며 창의적이고 혁신적인 웨어러블 테크놀로지를 개발하기 위한 향상된 디자인 방법론을 제안하는 것을 목표로 한다. 첫째, 웨어러블 기술의 발전 궤적을 분석하여 패션의 중요성의 증대와 UX(사용자 경험) 디자인 강화의 필요성을 확인한다. 또한 보다 창의적이고 혁신적인 아이디어를 촉진하기 위한 미래 사고의 적용을 강조한다. 둘째, 이 연구는 웨어러블 테크놀로지의 맥락에서 패션, 디자인, 기술의 다양한 접근 방식을 비교한다. 이를 통하여 각 분야의 요소를 융합하여 새로운 디자인 방법론을 제안한다. 셋째, 제안된 방법론을 적용하고 구체화하기 위해 웨어러블 테크놀로지 디자인 워크숍을 기획하고 진행한다. 이 연구의 결과는 웨어러블 테크놀로지 개발을 위한 종합적인 방법론으로 제시된다. 이러한 접근 방식은 테크놀로지 관련 융합 분야에서 디자인의 중요한 역할을 강조하며, 학술 연구와 산업 분야 모두에 중요한 사회적, 실무적 함의를 가지고 있다.

키워드

디자인 방법론, 웨어러블 테크놀로지, 패셔닝 테크놀로지, 미래적 사고, 사용자 경험 디자인, 다학제적 접근