BISCUIT RUN PARK PHASE 2 DEVELOPMENT
(Technical Report)

BALANCING SAFETY AND SURVEILLANCE: OPTIMIZING WEARABLE TECHNOLOGY INTEGRATION IN CONSTRUCTION WHILE ADDRESSING PRIVACY AND TRUST CONCERNS
(STS Research Paper)

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By
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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

Construction remains one of the most dangerous industries with high rates of injuries and fatalities. Construction workers account for 9% of all fatal injuries and 20% of non-fatal injuries in U.S. occupations (Almaskati et al., 2024). These hazards demand advancements that prioritize worker safety and community well-being (Choi et al., 2017). The integration of wearable safety devices has proved to reduce construction site risks and help prevent accidents by providing real-time monitoring. However, while these devices contribute to safer workplaces, they also introduce privacy and trust concerns, as workers are often apprehensive about continuous monitoring and potential data misuse.

This capstone project and thesis explore two interconnected areas in construction: the sustainable design and development of accessible public spaces and the ethical integration of wearable technology for enhancing safety. The technical portion focuses on the development of Biscuit Run Park, a 1,190-acre public green space situated between Route 20 and Old Lynchburg Rd that addresses the growing disparity of access to public recreational areas in Albemarle County (*(Future) Biscuit Run Park*, n.d.). The sociotechnical research applies the Technology Acceptance Model (TAM) to assess how perceived usefulness, ease of use, and privacy concerns influence workers' acceptance of wearable safety technology in construction (Choi et al., 2017). The Biscuit Run Park project and the study of wearable technology in construction are connected since they both share emphasis on fostering safer, more inclusive environments within the industry. Both projects highlight the need for integration of new practices and technologies that benefit workers, the environment, and the surrounding community alike. Designing Biscuit Run Park requires balancing community access to green spaces with environmental and safety standards which shows a responsibility to both community well-being and sustainable design

practices. Similarly, the study of wearable technology emphasizes the importance of implementing innovations that enhance worker safety without compromising privacy and trust. Together, these topics underscore the broader industry challenge of harmonizing technological advancements with ethical and sustainable practices that prioritize the welfare of individuals and communities.

Biscuit Run Park

The development of Biscuit Run Park is a response to Albemarle County's growing disparity for accessible green spaces as the Charlottesville area expands. Expected to be the county's largest park, this site will feature walking and cycling trails, athletic fields, pavilions, playgrounds, and scenic views to enhance quality of life and preserve natural resources (*(Future) Biscuit Run Park*, n.d.). Phase 1 was completed in October 2024 and included a paved entrance and an access road leading to a trailhead parking lot, while Phase 2 will expand roads and parking, and introduce sports fields and a trail system.

The technical challenge lies in designing these additions to coordinate with the park's "living with nature" theme. This project addresses the growing demand for sustainable public green spaces that support community health, accessibility, and environmental resilience. As Charlottesville expands, access to well-designed recreational areas like Biscuit Run Park becomes increasingly vital. The needs of nearby communities, including Avon Street, Mill Creek Village, Lake Reynovia, and Southwood Mobile Home Park, will be prioritized to ensure the park serves the people who benefit most directly. This project presents an opportunity to study how large-scale green spaces can meet diverse community needs while minimizing environmental impact and can serve as a model for sustainable urban planning in similar areas. In collaboration with an advisor from AMT Engineering, specific portions of Phase 2, including

paved trails, two athletic fields, and a stormwater detention basin will be re-designed to balance recreational use with environmental sustainability.

Research methods include analyzing case studies, reviewing design standards, and consulting with stakeholders to ensure the designs meet both community needs and regulatory standards. A site visit conducted after Phase 1 helped assess existing conditions and inform design proposals for Phase 2. The trail layout and grading will adhere to guidelines from the Virginia Department of Transportation (VDOT), AASHTO (American Association of Highway and Transportation Officials), and ADAAG (Americans with Disabilities Act Accessibility Guidelines).

For the athletic fields, potential design improvements will be explored based on cost estimations for various options, ensuring the design is both effective and budget-conscious. Using data from a VRRM analysis and requirements from the Virginia Department of Environmental Quality (VDEQ), permanent stormwater BMP facilities will be designed to manage runoff sustainably. Following these designs, a construction phasing plan will guide the implementation of a sediment detention basin for Phase 2.

The final deliverables will include detailed CAD drawings of trail layouts, athletic field designs, and stormwater management strategies, as well as a phased construction plan and cost estimates. These deliverables aim to create a sustainable park that serves as a model for balancing recreational needs with environmental stewardship, providing Albemarle County with a valuable community resource (*(Future) Biscuit Run Park*, n.d.; *Making Biscuit Run Park Available to Everyone,* 2023).

Balancing Safety and Surveillance in Wearable Technology Integration

The construction industry's labor-intensive nature poses significant risks, including falls, electrocutions, exposure to hazardous materials, and burns (*Common Accidents on Construction Sites*, n.d.). Engineers and safety experts have developed wearable technologies like smart helmets, exoskeletons, and location-tracking wristbands in order to mitigate these risks to construction workers (Kim et al., 2024). These devices enhance safety; however, they raise concerns over policy and trust since workers may feel uncomfortable with continuous monitoring of their movements and health-related data. Therefore, the challenge lies in integrating these technologies seamlessly into the complex, fast-paced daily operations of construction sites without causing disruptions or resistance from workers.

This study aims to answer key questions, including how wearables can be incorporated into construction workflows without infringing on privacy and what strategies can foster worker trust and acceptance for both safety and efficiency. To analyze these factors influencing wearable technology adoption in construction, this research will employ the Technology Acceptance Model (TAM), a widely used framework that examines how users come to accept and utilize new technology. Previous studies, such as those by Choi et al. (2017) and Okpala et al. (2022), demonstrate that concerns around privacy and usability impact the adoption of wearables across different construction sites. By employing TAM, this study can assess the sociotechnical barriers to wearable technology integration and identify ways to promote ethical adoption.

This study will analyze qualitative data from interviews and case studies to explore sociotechnical implications. Interviews with industry professionals and construction workers, including conversations with Melissa Colbert, a small residential construction company owner, will provide firsthand insights into privacy concerns and acceptance factors. Literature regarding

workplace surveillance, privacy rights, and trust will contextualize the findings in a sociotechnical context (Holden & Duffy, 2023). The overarching goal of this study is to aid in the development of practical guidelines to ethically integrate wearable technologies into construction firms for enhanced safety and trust among workers.

This research aligns with other findings that concerns around wearable technology in construction are rooted not only in technical but also in social and ethical issues. Studies by Choi et al. (2017) and Okpala et al. (2022) highlight that privacy, usability, and compatibility with safety protocols are critical to adoption. Ibrahim et al. (2024) found that in Nigeria, awareness of wearable technology remains low due to privacy-related mistrust and fears of data misuse, underscoring that privacy is a global concern. This correspondence in existing research highlights that privacy is a widespread concern with the adoption of wearable technology, and is not restricted by geographical or cultural boundaries.

The systematic review of wearable technology by Alsharef et al. (2023) emphasizes that transparency in data usage is essential for fostering trust, as confidence in technology can erode if data appears to be used for performance monitoring rather than safety. Awolusi et al. (2018) further assert that trust in the technology and employers' intentions is vital to acceptance. When workers view wearable devices as safety tools rather than surveillance mechanisms, they are more likely to use them. Thierer (2015) suggests that privacy and security concerns with wearable technology can be best addressed through industry guidelines, clear communication, and voluntary standards rather than rigid regulations, advocating instead for an approach that balances innovation with privacy protection through public feedback, adaptive technological solutions, and existing legal frameworks.

The integration of wearable technology in construction remains challenged by sociotechnical barriers, particularly privacy concerns and trust in data usage. This research proposes strategies to address these barriers and enhance worker acceptance of wearable technologies by utilizing and analyzing existing scholarship. Employing TAM will provide a structured understanding of the factors that influence technology acceptance in construction and offer insights on how to foster both safety and trust for worker's well-being.

Conclusion

In conclusion, this research offers valuable insights into addressing the challenges of creating safer, more accessible construction environments while maintaining ethical standards around privacy. Analyzing the development of Biscuit Run Park highlights how sustainable design can serve both community well-being and the needs of environmental protection for future green spaces development. Simultaneously, the study of wearable safety technology emphasizes the sociotechnical barriers that must be addressed for these innovations to be seamlessly accepted into the industry. Together, these studies emphasize the need to balance technological advancements in construction with respect for individuals and the surrounding communities.

By addressing these interconnected issues through this research this study aims to advance the understanding of how construction can evolve to prioritize ethical practices, community success, and worker safety. The insights gained from studying these topics will provide a foundation to guide the construction industry towards a more sustainable, inclusive, and ethically responsible approach.

References

Almaskati, D., Kermanshachi, S., Pamidimukkala, A., Loganathan, K., & Yin, Z. (2024). A review on construction safety: Hazards, mitigation strategies, and impacted sectors. *Buildings*, *14*(2), 526. https://doi.org/10.3390/buildings14020526

Alsharef, A., Albert, A., Awolusi, I., & Jaselskis, E. (2023). Severe injuries among construction workers: Insights from OSHA's new *severe injury reporting program*. *Safety Science*, *163*, 106126. https://doi.org/10.1016/j.ssci.2023.106126

Awolusi, I., Marks, E., & Hallowell, M. (2018). Wearable technology for personalized construction safety monitoring and trending: Review of applicable devices. *Automation in Construction*, *85*, 96–106. https://doi.org/10.1016/j.autcon.2017.10.010

Choi, B., Hwang, S., & Lee, S. (2017). What drives construction workers' acceptance of wearable technologies in the workplace?: Indoor localization and wearable health devices for occupational safety and health. *Automation in Construction*, *84*, 31–41. https://doi.org/10.1016/j.autcon.2017.08.005

Common Accidents on Construction Sites. (n.d.). Procore. Retrieved November 10, 2024, from https://www.procore.com/library/common-construction-accidents

Fugate, H., & Alzraiee, H. (2023). Quantitative analysis of construction labor acceptance of wearable sensing devices to enhance workers' safety. *Results in Engineering*, *17*, 100841. https://doi.org/10.1016/j.rineng.2022.100841

(Future) Biscuit Run Park. (n.d.). Albemarle County Parks & Recreation. https://www.albemarle.org/government/parks-recreation/biscuit-run-park#ad-image-7

Holden, B., & Duffy, V. G. (2023). Wearable technology safety and ethics: A systematic review and reappraisal. In H. Degen, S. Ntoa, & A. Moallem (Eds.), *HCI International 2023 – Late Breaking Papers* (Vol. 14059, pp. 390–407). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-48057-7_24

Ibrahim, K., Simpeh, F., & Adebowale, O. J. (2024). Awareness and adoption of wearable technologies for health and safety management in the Nigerian construction industry. *Frontiers in Engineering and Built Environment*, *4*(1), 15–28. https://doi.org/10.1108/FEBE-11-2022-0041

Kim, J., Lee, K., & Jeon, J. (2024). Systematic literature review of wearable devices and data analytics for construction safety and health. *Expert Systems with Applications*, *257*, 125038. https://doi.org/10.1016/j.eswa.2024.125038

Making Biscuit Run Park Available to Everyone. (2023). The Piedmont Environmental Council. https://www.pecva.org/resources/publications/piedmont-view/making-biscuit-run-park-available-to-everyone/

Okpala, I., Nnaji, C., Ogunseiju, O., & Akanmu, A. (2022). Assessing the role of wearable robotics in the construction industry: Potential safety benefits, opportunities, and implementation barriers. In H. Jebelli, M. Habibnezhad, S. Shayesteh, S. Asadi, & S. Lee (Eds.), *Automation and Robotics in the Architecture, Engineering, and Construction Industry* (pp. 165–180). Springer International Publishing. https://doi.org/10.1007/978-3-030-77163-8_8

Tabatabaee, S., Mohandes, S. R., Ahmed, R. R., Mahdiyar, A., Arashpour, M., Zayed, T., & Ismail, S. (2022). Investigating the barriers to applying the internet-of-things-based technologies to construction site safety management. *International Journal of Environmental Research and Public Health*, *19*(2), 868. https://doi.org/10.3390/ijerph19020868

Thierer, A. D. (2015). *The Internet of Things and Wearable Technology: Addressing Privacy and Security Concerns without Derailing Innovation. SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2494382