

PROPOSAL SUMMARY

Motivation. On June 4-6, 2024, the Burroughs Wellcome Fund (BWF) and the Milken Institute Science Philanthropy Accelerator for Research and Collaboration (SPARC) hosted *the Supporting Philanthropic Engagement to Advance Health Equity in Science Retreat* in North Carolina, where the PI (Toussaint) was an invited participant. A summary of the outcomes of the retreat was later published and also served to inform the *Health Equity in Science (A Giving Smarter Guide)* report from the Milken Institute. The **reports recommend the establishment of digital health technology (DHT) hubs for equitable outcomes** as a critical mechanism to build community-centered research systems. Furthermore, these reports emphasize the potential opportunity for DHT and AI tools to mitigate health disparities through efforts such as co-designing with stakeholders (e.g., clinical and patient communities, public health researchers, implantation scientists), increase overall technological and data literacy, and cross-disciplinary training of all stakeholder communities. In order to meet these recommendations and contribute to the realization of DHT hubs for equitable outcomes, it is important to create a simulation ecosystem that will facilitate the prototyping of stakeholder-informed DHTs and the associated cross-training. Thus, **the goal the proposed effort** is to develop a **health innovation technology sandbox (HITS)** as a deployable model for inclusive, DHT prototyping and validation. This goal will be achieved through the following major aims: **1)** establish a research and design methodology for improving the diagnostic accuracy of DHTs for everyone; **2)** develop strategies for technology co-design with stakeholders; **3)** create a program for DHT and data literacy; and **4)** establish a DHT training module for undergraduate seniors in STEM. **HITS** brings together **expertise in engineering, design, and health**, to promote DHT development, testing, and expands interdisciplinary collaborations. **The proposed work is well-aligned with the recommendations of the aforementioned reports and with the mission of the BWF to eliminate health disparities and advance health for all people through scientific advancement.**

	Basic Concepts	Training Modules	Health Applications
Optical sensors (Q1)	Optical waves, light sources, photodetectors, polarizers, light-tissue interaction	EAGLE, flexible printed circuit boards, microelectronics, device encapsulation, Bluetooth wireless transmission, basic signal analysis and troubleshooting	Photoplethysmography (PPG), pulse oximetry, transcutaneous bilirubinometry, body temperature
AI-enabled hardware (Q2)	Embedded system and edge computing, AI accelerators, lightweight models	Microcontroller programming for AI, ML model deployment on edge devices	On-device inference of behavioral patterns, AI-enabled diagnostic support at the edge
AI Monitoring through Computer vision (Q3)	Image Acquisition, Image processing basics, multi-camera pose estimation and 3D reconstruction, object tracking	Computer Vision technology, wearable image acquisition design	AI-based monitoring: elderly fall detection, gait recognition, early diagnosis/intervention, medication adherence
Kinematic sensors (Q4)	Operating principles of accelerometers, gyroscopes, and magnetometers. Rotating frames, inertial forces, and deformation of sensing structures.	Inertial measurement unit deployment and data collection. Post-processing of data to identify and eliminate artifacts. Band-pass filters. Wavelets based filters. Simulation and detection of falls using anthropomorphic test devices (humanoid dummies).	Track onset or progression of central nervous system disorders, such as Alzheimer's, and Chronic Traumatic Encephalopathy, through the monitoring of gait, balance, etc. Detect falls, blows, and other trauma inducing events.

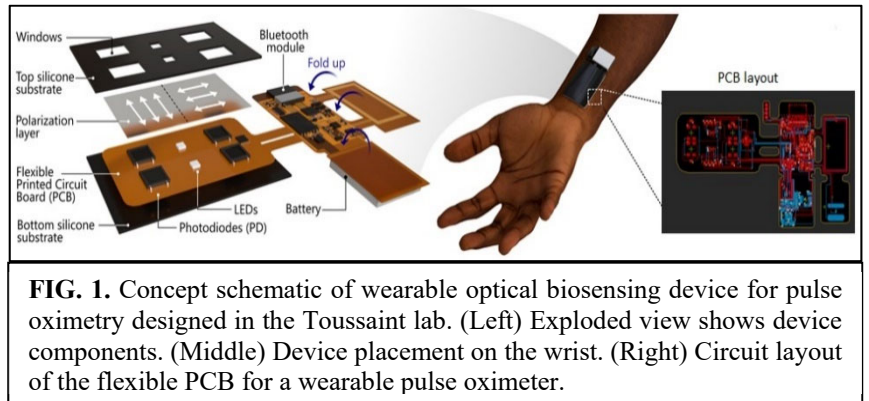
Table 1. Summary of training per topic area. The corresponding quarter (Q1-Q4) for which each activity would take place is indicated.

Approach. The primary technology core areas that will be the basis for DHT prototyping and validation, and cross-training are **optical sensors (Toussaint)**, **AI-enabled embedded computing platforms (Zhou)**, **computer vision (Kimia)**, and **kinematic sensors (Kesari)**. Prototyping and validation will serve as the foundation for the **cross-training of HITS trainees**. Thus, HITS will comprise two critical training components: seminar-style short lectures on select topics in the aforementioned areas, and hands-on training modules. **Table 1 provides a summary of the proposed cross-training, which will include data literacy across these various technology platforms.** Training materials will be compiled and archived for dissemination. Core training will be supplemented by a **design research integration framework** (led by **collaborators B. Altringer Eagle and L. Manfredi**) that incorporates user insights into technology development. In this case a lightweight module consisting of three brief introductory sessions will equip students with a flexible framework for **technology co-design by incorporating user insights** into their technical work. The students will be provided with a simple, adaptable toolkit of design research methods that they can apply independently throughout their projects. Students will receive templates for user interviews, observation protocols, and lightweight usability testing that they can implement at their own pace alongside their technical development work. This structure respects the students primary focus on the core technical areas while giving them practical tools to enhance the real-world applicability of their health technology innovations. By incorporating a design framework, HITS will enable broad usability testing of DHTs, as well as feedback from clinical collaborators and other stakeholders, in order to engineer a path to **ensuring diagnostic accuracy** across diverse demographics. To further facilitate this, the PI and team will request approval from **Brown University's IRB** for participant testing of multiple DHTs, Furthermore, through **the Center for Digital Health** (directed by the PI), student training will further be diversified by seminars and workshops on data science, implementation science, biostatistics, and community engagement.

Examples of two of the technical core training modules are provided below.

Optical sensors and wearable device development module (Toussaint).

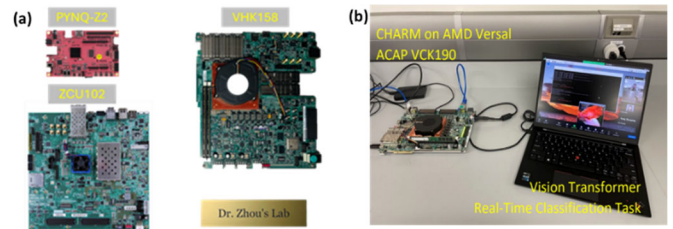
The optical sensors module of the cross-training curriculum will provide students with hands-on experience in building optical wearable devices (see Fig. 1). Drawing from the Toussaint Lab's experience¹, this module will also introduce students to printed circuit boards (PCB) design using EAGLE, where they will learn to create and modify schematics and board layouts for biosensing circuits (Fig. 1 inset). Students will learn circuit



assembly and use of equipment—such as power supplies and infrared cameras—to troubleshoot issues such as improper connections, thermal hotspots, and signal noise. In addition, students will learn how to interpret photoplethysmography signals and evaluate device performance, as well as basic device communication protocols (e.g., Bluetooth Low Energy 5.0), for real-time, wireless biosignal transmission.

AI-enabled hardware and efficient sensing-computing-reasoning system (Zhou).

This training module equips students with the skills to design, build, and optimize intelligent systems that integrate sensing, computing, and reasoning — all supported by AI-enabled hardware (see Fig. 2a). The focus is on end-to-end understanding of the system pipeline and hands-on implementation across hardware and software layers. Students will be introduced to AI-enabled embedded computing platforms that interface directly with sensor I/O, enabling real-time data acquisition, signal processing, and AI inference. This is enabled by Dr. Zhou's years of successful implementations of AI-enabled embedded computing platforms in various forms and power budgets for broad application domains including deep learning², intelligent optical sensing³, computer vision⁴, and autonomous system⁵. Students will learn to deploy and iterate on algorithms that process and analyze streaming sensor data, with outputs visualized live on a monitor. The module emphasizes hands-on learning, allowing students to modify software in real time (as captured in Fig. 2b), prototype new algorithms, and explore advanced embedded platforms available in the lab.



Brown U. core team. The team will comprise the PI, K. Toussaint, Jr., Ph.D. (Electrical Eng), P. Zhou, Ph.D. (Electrical Eng), H. Kesari, Ph.D. (Solid Mech.), B. Kimia, Ph.D. (Electrical Eng.), and M. Dansby Russell, Ph.D (Engineering Ed). **Collaborators.** B. Altringer Eagle, Ph.D. (Design), and L. Manfredi (Design).

Program evaluation and Outcomes. Formative evaluation will be carried out by collaborator (Dr. Dansby Russell). The evaluation will be used to gauge student experience and technical competency, and will include a combination of pre-surveys and post-surveys that assess student perceptions over time, and a pretest/posttest technical assessment to measure the potential growth in student understanding of technical material from the class onset through to its conclusion. Evaluation will also look at the number of peer-reviewed journal and conference publications and presentations involving student trainees (resulting from the work).