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Reshape Safe, Sustainable Labs and Makerspaces on Campus:
An Experimental Study on Material Flow through Human-centered System Design

This study explores disposable lab/makerspace material flow on campus using Human-centered System Design (HCSD). We conduct the experimental study for sustainable innovation at Massachusetts Institute of Technology (MIT). Since makerspaces and labs occupy 25% of the physical footprint at MIT, understanding material flow is crucial to this study. We research disposable material flow to envision building safe, sustainable makerspaces and labs on campus and provide a case study.

Keywords: sustainable, safe, material flow, human-centered system design, laboratory

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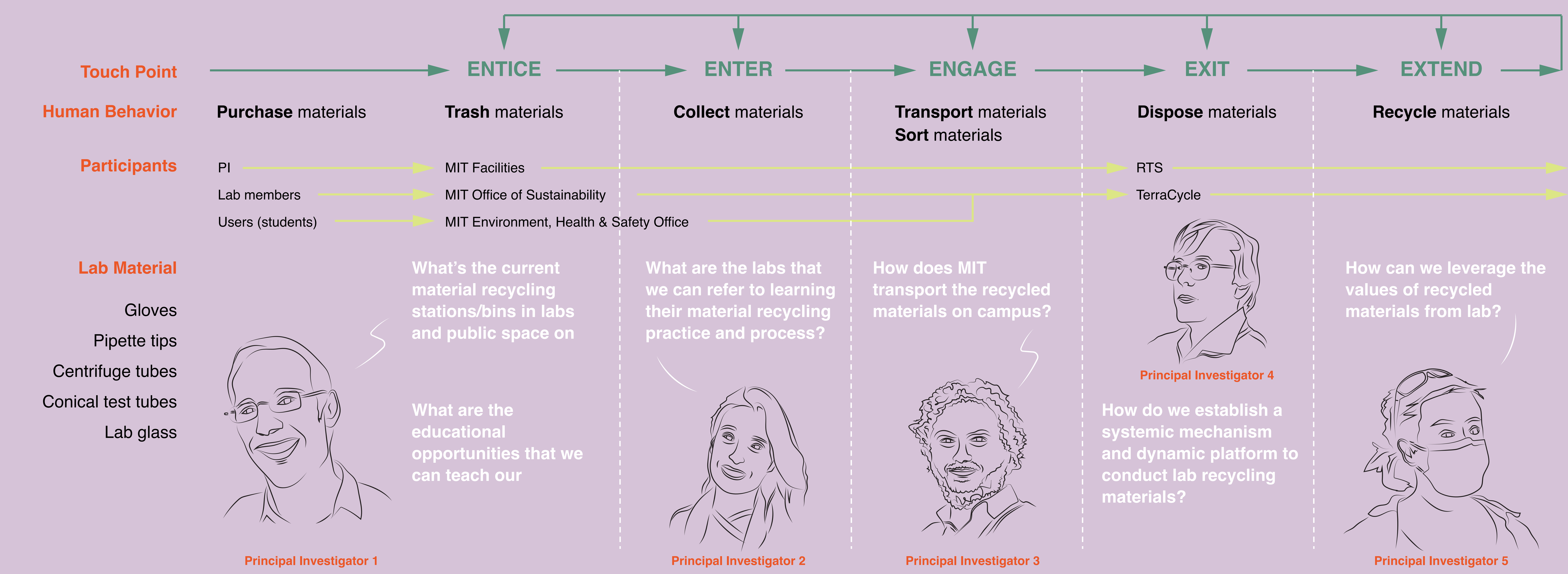
Project Background

At MIT, labs and makerspaces take up only 25% of physical space but collectively consume over 65% of campus energy [1, 2]. MIT aims to achieve net-zero emissions by 2026, eliminate direct emissions by 2050, and reduce greenhouse gas, achieving a 32% reduction of overall emissions by 2030. To address these challenges, we researched disposable lab/makerspace material flow to envision how to build safe, sustainable labs/makerspaces on campus. We analyzed pre-survey results and conducted field research. We visited four labs—biological, chemical, material, and mechanical engineering—and two campus makerspaces: The Deep and Metropolis [3] to conduct interviews and surveys with principal investigators (PIs), managers, and students.

Related Works—Human-Centered System Design

We used HCSD to track and analyze disposable material. HCSD is an experimental framework merging IDEO's version of human-centered design [4] (e.g., user journey) with methodologies from system engineering (e.g., Object-Process Methodology) [5] and system architecture [6]. Earlier studies used HCSD to redesign a circular makerspace on campus [7], recreate a public learning space in a library [8], and re-establish a campus tour experience [9]. We applied a modified 5E-experience design model [9] integrated into an HCSD framework to visualize journeys of lab/makerspace disposable material and people's behavior to compare the pros and cons of sustainable material procurement cost, recycling process, disposal, and storage.



Case Study—Experimental Research Approaches and Results

We categorize disposable material flow into four phases: procurement, inventory management, recycling, and disposal. The five most common disposable lab items at MIT are nitrile gloves, pipette tips, pipette boxes, centrifuge tubes, and conical test tubes, so these are the items we track.

1) Tensions exist between individual behavior and institutional needs

The requirements of labs/makerspaces, users, and the institute were various. How can we create a resilient system of different modules based on the needs of labs/makerspaces and the institute? As Figure 4 shows, 60% needed support from both institutions and individuals to handle recycled waste.

2) Smart inventory management can reduce over-purchasing

Most PIs use an inventory system showing what disposable items they need to repurchase, how many, and when. One way to reduce material waste (output) is to control material inventory (input).

3) Safe, sustainable labs/makerspaces start with people's behavior

Building safe, sustainable labs/makerspaces is challenging if we don't understand people's behavior. People know purchasing sustainable products is the right thing to do, but when making procurement decisions, still consider tradeoffs between the cost of products and their time, and the value they contribute.

4) Clear wayfinding in labs/makerspaces empowers users to cultivate good habits

Transparent communication in a lab/makerspace educates users on how to use equipment properly, make responsible decisions regarding material purchasing or energy savings, and emphasize safe, sustainable initiatives and culture.

Discussion and Conclusion

1) Design for complex, systematic challenges

We considered material procurement, usage, recycling, storage, and disposal processes and included non-material-flow: culture, education, behavior, and regulation. We need more effort from PIs, universities, and students: a collective commitment to address systemic challenges.

2) Designers' roles in building safe, sustainable labs/makerspaces

Designers spend much time in labs/makerspaces conducting experiments to validate their ideas. As users, we applied the HCSD framework to refine each touchpoint connecting not only safety, carbon neutrality, and energy efficiency, but also people's behavior, education, and cultivation of eco-friendly culture.

3) Platform-level solution

Building a safe, sustainable lab/makerspace is a series of complex, systemic social-technological problems. How do we find a platform-level solution to address them? MIT has collaborated with Rheaply, an online asset-exchange software company, for three years to make materials, resources, and services in labs/makerspaces more visible and easier to build an impactful platform-level solution.

Author's Bio

Sheng-Hung Lee is a designer, MIT PhD researcher, and Chair at IDSA Boston. He is trained as an industrial designer and electrical engineer, and his approach to problem solving is influenced by his passion for how design and technology impact and can be integrated into society. He has been invited to be a jury member for multiple international design competitions including IDEA, and Spark Design Award. His works have won prestigious awards including IDEA, iF, Braun Prize, and Core77, and have been showcased in Venice Design Week, Cooper Hewitt Museum, and MIT Wiesner Art Gallery.

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