Fixers' Ledger: Enhancing Repair Capabilities by Capturing Tacit Knowledge in Community Electronics Repair

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Abstract—In repair and maintenance, a significant amount of experiential knowledge derives from hands-on trial-and-error approaches to fixing electronic devices, particularly in repair cafés where volunteers contribute their time to repair electronic items. These practitioners lack a system that can effectively capture and facilitate the diagnosis of electronic items. This diagnostic capability emerges primarily from experience; therefore, we propose the Fixers' Ledger, a technological intervention designed to capture and document tacit knowledge in electronics repair contexts. The system integrates multiple imaging, sensing, and data capture capabilities to record the non-linear troubleshooting processes employed by repair practitioners. By visualising repair workflows and generating retrievable documentation via barcode technology, the system aims to bridge the gap between tacit and explicit knowledge in repair practices, thereby contributing to both the democratisation of repair expertise and sustainable consumption through extended product lifespans.

I. Introduction

Electronic waste represents one of the fastest-growing waste streams globally, with 62 million tonnes generated in 2022 alone and projections reaching 82 million tonnes by 2030 [1]. Despite the staggering volume, less than a quarter (22.3%) of this e-waste is documented as properly collected and recycled [1]. This crisis is exacerbated by limited repair options, which the Global E-waste Monitor 2024 identifies as a key challenge contributing to the growing problem [1].

Our research explores how community-based repair initiatives, specifically repair cafés, serve as sites where significant repair expertise emerges through collaborative practice [2]. Through ethnomethodological observation at repair cafés in the UK, we have identified four key dimensions of tacit knowledge in repair settings: experiential learning, adaptive troubleshooting, visual heuristics, and collaborative knowledge ecosystems. This tacit knowledge, developed through hands-on experience and difficult to formalise, is fundamental to effective repair but remains largely uncaptured and undocumented [3].

From our field observations, we found that repair café volunteers currently utilise paper, notebooks, or sticky notes affixed to repaired products to document intervention details. This approach presents notable challenges, particularly when volunteers operate under time constraints, resulting in incomplete knowledge capture. Additionally, when volunteers employ smartphones for troubleshooting or repair guidance, they navigate through multiple digital resources to determine relevance. Consequently, the decision-making process regarding what information applies to specific electronic device repairs becomes lost in this navigation process.

Similarly, we observed volunteers using image search platforms to identify components for ordering or to comprehend specific parts. This process involves evaluation of multiple sources, with decisions based on experiential knowledge and iterative approaches to locate appropriate references. Volunteers also document disassembly processes through photography to facilitate reassembly. Furthermore, our observations indicate potential applications for thermal imaging in identifying current flow patterns and diagnostic indicators.

The gap between existing documentation approaches (manuals, online tutorials, videos) and the rich, embodied knowledge of experienced repairers presents an opportunity for intervention [4]. When electronic devices break down, the diagnostic process often relies on implicit knowledge that has not been effectively codified [5]. Our proposed prototype aims to address this challenge by providing a tool specifically designed to capture diagnostic knowledge during repair processes, with particular attention to troubleshooting pathways and the process of elimination that characterises expert repair work.

By developing tools that effectively capture and share tacit knowledge in repair contexts, we aim to democratise repair expertise, extend product lifespans, and contribute to more sustainable consumption patterns [6]. This work is situated at the intersection of Computer-Supported Cooperative Work (CSCW), sustainable HCI, and circular economy research, addressing both technological and social dimensions of the repair knowledge gap [7, 8].

II. Related Work

Repair work is more of a hands-on task where physical tools are essential for diagnosis. However, digital tools can also help capture and retain knowledge. That is the premise of this prototype. This section explores how existing literature informs our understanding of repair practices and knowledge capture methodologies.

Physical tools play a fundamental role in electronics repair. Technicians typically employ multimeters, oscilloscopes, and thermal cameras to identify faults beyond human sensory capabilities. These instruments function as sensory extensions, allowing repairers to detect electrical anomalies, thermal variations, and visual defects. These tools become increasingly intuitive through repeated practice, with expertise developing over time. Technicians develop an understanding of these tools through embodied cues they cultivate over time, which helps them associate symptoms with causes and enhances their diagnostic work. As Sennett [9] discusses in his examination of craft and expertise, skilled practitioners develop what he terms "material consciousness" - a heightened awareness of material properties gained through repeated physical engagement. This embodied expertise aligns with phenomenological perspectives where knowledge emerges through direct material engagement rather than abstract conceptualisation, as explored in Dourish's work on the materiality of information [10].

The theoretical framework of distributed cognition, developed by Hutchins [11], offers valuable insights for understanding repair expertise. Rather than viewing knowledge as contained within individual minds, this perspective recognises how expertise distributes across human actors, technological artefacts, and environmental contexts. Repair cafés serve as exemplary sites of such distribution, where knowledge emerges through collaborative encounters between repairers, tools, and material properties of malfunctioning devices. This conceptualisation provides critical guidance for designing technologies that acknowledge the socio-material dimensions of repair knowledge.

The current research focuses on developing devices that help repairers identify diagnostic cues that typically remain implicit in practice. Expert repairers recognise patterns and anomalies that novices cannot detect due to insufficient experiential knowledge. By creating technological interventions that augment diagnostic capabilities through highlighting these cues, it becomes possible to democratise repair knowledge and improve repair outcomes. Such systems function as cognitive extensions for the repairer, amplifying existing capabilities while supporting the development of new skills.

Ahmed et al. [12] demonstrate in their study of mobile phone repair practices in Bangladesh how repair knowledge is collaboratively constructed and transferred in communities with limited resources. Their research shows that repair involves complex knowledge networks that extend beyond formal documentation. Similarly, Houston et al. [13] examine how values in repair communities influence which knowledge is valued and preserved, and how repairers negotiate between environmental, economic, and social priorities when making repair decisions.

Mobile technologies can be used for repair documentation due to their ubiquity and rich sensor ecosystems. Smartphone-based systems provide accessibility while integrating cameras, microphones, and connectivity necessary for comprehensive knowledge capture. However, existing mobile applications for repair typically focus on accessing pre-existing documentation rather than capturing new knowledge or highlighting diagnostic cues that facilitate effective troubleshooting.

The Fixers' Ledger builds upon these research foundations while addressing limitations in current approaches by explicitly focusing on diagnostic pathways, integrating multimodal data, and representing non-linear troubleshooting processes. By incorporating principles from embodied interaction and patterns of distributed knowledge observed in repair communities, the system bridges the gap between individual expertise and communal knowledge resources.

III. Imagined Prototype: : Fixers' Ledger

The Fixers' Ledger prototype comprises a tablet-based digital system with integrated hardware accessories to support electronic repair documentation and knowledge capture. The system enables technicians to record their diagnostic processes, generate retrievable documentation, and build a knowledge repository for future repair reference.

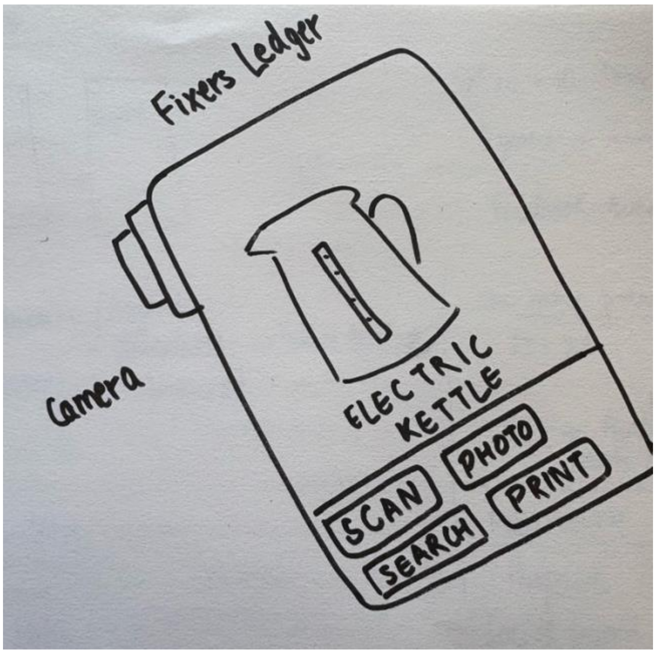

Figure 1

A. *User Interface and Functionality*

Figure 1 illustrates the primary interface featuring a tablet with an integrated camera and four main functions: SCAN, PHOTO, SEARCH, and PRINT. The interface displays the device being repaired (an electric kettle) and prioritises ease of use during active repair work.

The system incorporates a knowledge tree visualisation (Figure 2, Screen 1) that presents repair pathways as branching decision paths, reflecting the non-linear exploration characteristic of expert diagnostic processes. The companion decision tree functionality (Screen 2) allows repairers to document critical decision points with a PRINT function for externalising these pathways.

The barcode generation capability (Figure 2, Screens 3-4) represents a key innovation. The system produces barcodes containing encoded repair information that can be affixed to repaired items, creating a physical link between devices and their repair histories. This approach embeds knowledge within objects themselves, drawing on concepts of distributed cognition.

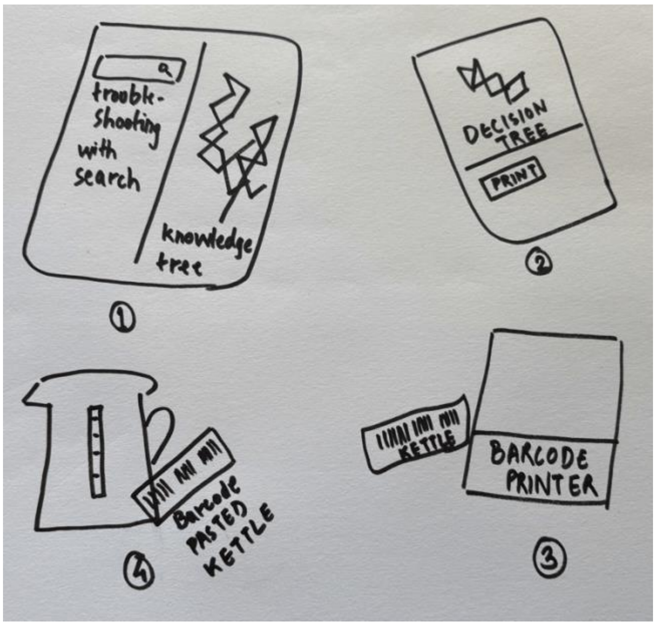

Figure 2

B. Integrated Tools and Capabilities

As shown in Figure 3, the system incorporates multiple tools to capture the multisensory nature of repair expertise:

- Magnification capabilities with dedicated lighting functions for detailed visual inspection
- Audio recording with automatic transcription to convert verbal observations into text
- External probe connections for electrical measurements and diagnostic data integration
- Zooming functionality for detailed component-level inspection

These features address different aspects of tacit knowledge in repair practices, from visual pattern recognition to articulating implicit reasoning during manual tasks.

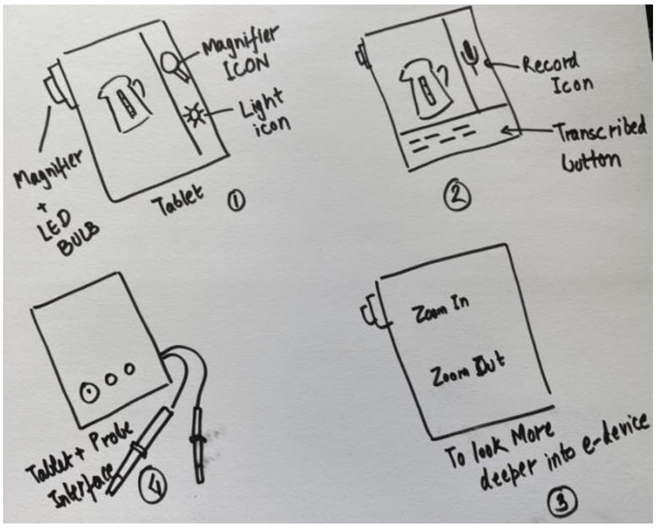

Figure 3

C. Implementation Architecture

The prototype can be implemented using commercially available components:

1. A ruggedised tablet computer with an integrated camera system
2. Digital microscope attachment with LED illumination
3. Thermal printer module for barcode generation
4. Measurement probes with tablet connectivity
5. Custom software on cross-platform frameworks

This modular architecture enables flexible deployment across repair contexts from community repair cafés to professional service centres, with expandability for additional sensors or measurement capabilities as needed.

IV. Responsible innovation

The Fixers' Ledger embodies responsible innovation by directly engaging with sustainability challenges, democratic knowledge sharing, and ethical data practices. The system's design is specifically oriented toward extending product lifespans by enhancing repair capabilities within community contexts.

The tablet-based documentation system addresses sustainability in multiple dimensions. First, by facilitating successful repairs through better diagnostic support, the system directly reduces waste by keeping products in use longer. Research indicates that unsuccessful repair attempts often lead to premature disposal of potentially salvageable devices [13]. The Fixers' Ledger's integration of visual capture, measurement tools, and knowledge repositories increases repair success rates, particularly for novice repairers.

The barcode functionality represents an approach to product lifecycle documentation that aligns with circular economy principles. By attaching repair history directly to products, the system creates what Strasser terms "object biographies"—documented histories that travel with products and strengthen their value within circular systems [14]. This approach challenges the information asymmetry that often creates barriers to repair and reuse.

From a social equity perspective, the tablet-based system democratises access to repair knowledge that has traditionally been restricted to manufacturer service networks or professional technicians. As Ahmed et al. [12] document in their study of mobile phone repair communities, access to repair documentation significantly impacts who can perform repairs and under what conditions. The Fixers' Ledger's focus on capturing and sharing tacit repair knowledge addresses the "*right to repair*" not merely as a legal right but as a practical capability supported by appropriate documentation tools.

The system's design prioritises accessibility across different skill levels. The intuitive interface with features like magnification, recording, and integrated measurement tools acknowledges varying technical expertise among repair practitioners. This inclusive design approach recognises that practical repair expertise emerges not solely from technical knowledge but from communities of practice where tools and knowledge are shared [7].

Furthermore, the prototype addresses data ethics concerns through its offline-first architecture, storing repair documentation locally before optional synchronisation with shared repositories. This design respects repairer autonomy in determining which knowledge to share while enabling community knowledge building. The explicitly collaborative design of the knowledge trees and decision pathways acknowledges repair as a collective rather than individual practice.

Environmental considerations extend to the prototype itself. The system utilises existing tablet hardware rather than creating dedicated single-purpose devices, reducing additional material requirements. The thermal printing technology for barcodes minimises consumable waste compared to traditional label printers, using heat-activated paper that requires no ink cartridges.

Through these design choices, the Fixers' Ledger exemplifies how digital tools can support sustainable practices by documenting them and actively facilitating and enhancing the embodied expertise needed for successful repair work.

V. Author Bio

Pranjal Jain is a third-year PhD researcher at the EPIC (Enhancing Human Interactions and Collaborations with Data and Intelligence Driven Systems) Centre for Doctoral Training at Swansea University's Computational Foundry. His research explores the development of systems that support skill development and social sense-making, particularly focusing on how digital tools can extract and capture tacit knowledge within repair settings.

His work employs an ethnomethodological approach, centring on the lived experiences of repair café participants. Using co-design methods, his research aims to develop tools that support decision-making and process elimination in repair contexts, ultimately contributing to a repository of experts' tacit knowledge that can be made accessible and teachable to novices.

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