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Understanding the Role of Supportive Tools in Repair: Exploring Repair as an Embodied Practice

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Abstract. Community-based electrical and electronic repair cafés rely extensively on tacit knowledge, presenting challenges for designing supportive tools in non-standardised and dynamic environments. Without adequate tools to capture this knowledge, community repair initiatives may face challenges in sustaining effective retention and sharing of repair knowledge. To address this, an ethnomethodological study was conducted in a UK-based repair café. Through immersive observations and conversations with expert repairers, we examined how they approach diverse range of repairs presented to them. Focusing on understanding their diagnostic strategies and the tools they employed. The preliminary findings revealed the intricate socio-technical dynamics among repairers and devices, where repair unfolds in an experiential, collaborative, and adaptive manner. The interplay between intuitive practices and systematic approaches emerged as a key feature, emphasising the importance of situated actions. By exploring these practices, we sought

insights into how future tools could better support repair's nuanced and collaborative nature. These tools could enhance trouble-shooting capabilities and extend the lifespan of devices.

Introduction

The repair of electrical and electronic devices is increasingly seen as vital for sustainability and waste reduction in consumption-driven societies (Bakker et al., 2014; Raihanian Mashhadi et al., 2016). Electrical repairs address components like wiring, motors, and switches, while electronic repairs focus on faults in semiconductors, integrated circuits, and microcontrollers. Both practices extend device lifespans, yet electronic repair underpins much of modern technology (Kalantidou et al., 2023; Vinck, 2019).

Community-based initiatives, known as *repair cafés*, have emerged to tackle these repairs collaboratively. They prioritise sustainability, skill-sharing, and community participation over pure efficiency (Keiller and Charter, 2014, 2016), relying heavily on tacit knowledge that is challenging to formalise (Collins, 2010). Although diagnostic tools (e.g., multimeters, oscilloscopes, soldering equipment) are common (Ahmed et al., 2015), the ability to identify faults often relies on practical reasoning and sensory awareness developed through hands-on experience (Polanyi, 1966; Collins, 2010).

Despite the prominence of tacit knowledge in community repair, existing studies have largely examined professional environments (Orr, 1996) or individual DIY (Sas and Neustaedter, 2017), leaving gaps in understanding grassroots repair practices (Houston et al., 2016). Current tools seldom capture or harness this informal know-how (Rosner and Ames, 2014), limiting the effectiveness of repair cafés. Özçelik and Löchtefeld (2024) argue that tools should not only aid diagnostics but also foster the elicitation and sharing of expert insight.

This paper presents preliminary findings from an ongoing ethnomethodological study exploring how supportive tools can better elicit, capture, and leverage tacit knowledge in community-based electronic repair. Using immersive fieldwork at a UK-based repair café, we examined fault diagnosis, adaptive problem-solving across diverse devices, and collaborative repair practices. Guided by Garfinkel (1967)'s ethnomethodology, our in-situ observations and contextual inquiries with expert repairers reveal key dimensions of tacit knowledge in grassroots repair work. The following questions guided our research:

1. **RO1**: How do repairers in community settings acquire and apply tacit knowledge?

2. **RQ2**: How can supportive tools be designed to enhance the elicitation and utilisation of tacit knowledge?

Related Work

Tacit knowledge, introduced by Polanyi (1966) and expanded by Collins (2010), is vital in repair settings, where its informal, context-specific nature eludes codification (Orr, 1996; Sennett, 2008). In Industry 4.0, capturing such knowledge aids complex decision-making (Ullah, 2020; Martinetti et al., 2020), and repair contexts offer in-situ insights appealing to HCI and CSCW (Houston et al., 2016). However, research commonly overlooks breakdowns and reuse (Garfinkel, 1967; Suchman, 1987), in favour of seamless functionality, disregarding inevitable failures (Dourish and Bell, 2011). This reveals a gap in human-technology design.

Jackson and Kang (2014) observes that HCI's focus on *"up-front design"* underestimates long-term human-object relations shaped by maintenance and repair—activities overshadowed by design-centric perspectives. Repair spaces foster social cohesion, skill development, and environmental consciousness (Houston et al., 2016), and diverse informal repair ecosystems thrive on collaboration, innovation, and shared knowledge (Rosner and Ames, 2014). Nevertheless, these underexplored dimensions highlight the significance of everyday repair work in shaping sustainable technology lifecycles and illuminating new design opportunities.

While community repair is linked to the circular economy through practices like tinkering and care (Van Der Velden, 2021), less attention is paid to tacit knowledge as a driving force. Jung et al. (2021) highlight the contingent nature of repair via *"repairedness,"* yet current systems rarely capture this situated knowledge. Similarly, Castle-Green and Sailaja (2024) show how smart devices are often excluded due to perceived difficulties, revealing gaps in collective practices. Thus, sustaining repair hinges on efficiently circulating tacit knowledge.

Foundational theories illuminate this process: Schön (1983) critiques codified expertise, stressing reflection-in-action; Suchman (1987) emphasizes the contextual nature of human action; and Hutchins (1995) demonstrates how cognition is distributed across people, tools, and spaces. Additionally, symbolic interactionism (Blumer, 1969) reveals how repairers co-construct meaning through shared engagement with objects and peers, highlighting the social complexity of tacit knowledge exchange. Despite these insights, tools for eliciting and preserving tacit repair knowledge remain scarce (Orr, 1996). Narrative approaches (Wenger, 1998) and multimodal support (Kress, 2010) can enhance learning and reflection. This study addresses this gap by illustrating how repair practices integrate individual and collective knowledge, forming a model of collaborative work that extends beyond conventional design philosophies.

Methodology

An ethnomethodological approach (Lynch, 1993) was adopted, positioning researchers as curious observers in a repair café. Alongside observation, the first author also served as a volunteer, learning basic repair tasks and shadowing expert repairers. This participatory role afforded deeper insights into the “lived work” of repair, revealing how tacit knowledge is demonstrated, communicated, and developed in practice.

Observations focused on moments of collaborative problem-solving, mutual teaching, and shared use of tools and resources. The first author took handwritten field notes each session to capture café routines and member challenges, supported by photographs documenting spatial layout and repair artefacts. These visuals illuminated how workspace organization—or disarray—shaped the repair process and the knowledge repairers drew upon.

To supplement observational data, semi-structured interviews were conducted with three expert repairers chosen for consistent involvement, demonstrated skill, and reflective practices. The interviewees included a robotics-focused PhD student, a full-time car workshop owner, and a retired engineer who had volunteered weekly since early 2024. These interviews explored how their existing knowledge was applied and adapted in a community repair setting, highlighting challenges, strategies, and tacit forms of expertise.

Data collection spanned four consecutive Sundays (each five hours). The first session built rapport and familiarity, followed by three Sundays featuring embedded interviews with one expert per week. Transcribed data was analysed using ATLAS.ti [1]. A deductive thematic approach (Braun and Clarke, 2006) guided systematic coding and theme development, conducted independently by the first and second authors. Regular data sessions resolved coding differences and refined themes, which were then cross-referenced with field notes to ensure coherence and analytical validity.

Findings

As this study reflects an early stage of our investigation, our findings reveal that a significant portion of the repair expertise and accomplishment stems from prior experience, trial-and-error approaches and pattern recognition from previous fixes. Repair expertise integrates logical reasoning with intuitive insights, utilising visual cues in problem-solving and exchanging knowledge through guidance and collaboration. We found that despite the availability of repair guides, successful repairs depend heavily on tacit knowledge. As shown in figure 1, the data illustrates the intricate socio-technical dynamics between repairers and devices, where repair unfolds as an experiential, collaborative, and adaptive process. Repairers use diverse strategies, including hands-on troubleshooting, trial-and-error diagnostics, visual pattern recognition, and collaborative knowledge sharing.

[1] https://atlasti.com/

Experiential Learning

Repairers primarily develop expertise through hands-on, trial-and-error experiences, as evidenced by the methodical approach observed during vintage radio restoration. Their reliance on accumulated experience—captured by statements such as,

> "*...It's a type of radio that somebody brings in, and just because I've done them before, I now know what the most likely thing that has happened is. It won't turn on and the screen won't turn on. But this light here will turn on like, oh, that means this particular part in the radio has failed...*"

—indicates the importance of in-situ documentation and real-time annotation to foster reflective learning, aligning with Kolb's experiential learning theory (Kolb, 2014).

Adaptive Troubleshooting

Repairers initially employ systematic diagnostic protocols but fluidly transition to improvised approaches when confronted with non-standard breakdown scenarios. As one participant explained:

> "*You start with easy stuff and get more and more difficult as you go on...I often have the instinct to take it all apart and figure it out myself...You are doing it by more intuition*"

This shift reflects the application of tacit knowledge and accumulated experience, rather than a real-time transition through stages of expertise. Dreyfus et al. (1980) describe expertise as a long-term development from rule-based novices to intuitive experts. While a repairer's initial reliance on systematic checks may resemble earlier stages of this model, their ability to improvise at the moment demonstrates the application of pre-existing expertise and experiential understanding.

Even highly experienced repairers may begin with structured procedures, but their swift adaptation when those fail is a hallmark of developed intuition—an ability shaped by repeated exposure to diverse repair scenarios. As such, there is a need for flexible digital tools that support both guided diagnostics and open-ended exploration, aligning with Klein (2008) naturalistic decision-making framework.

Visual Heuristics and Pattern Recognition

Visual cues play a critical role in how repairers diagnose faults. They often begin with simple visual checks—such as verifying whether the device is powering on, inspecting for loose wiring, and checking if current is flowing—before progressing to more detailed inspections. We observed, one repairer tended to disassemble a device immediately to investigate internal components, while another one emphasised the importance of restraint, noting that issues are often resolved through basic visual assessments without full teardown. Repairers' reliance on pattern recognition was evident throughout, as they drew on their past experiences to guide their next steps. One participant described this process as:

> "*You're basically thinking at the back of the mind, which is subconsciously you're figuring out what should be your next step...*"

This kind of intuitive visual reasoning reflects the development of tacit knowledge—an internalised, experience-driven *"library"* of fault patterns that allows for rapid, non-verbal decision-making in repair contexts. This aligns with Ylirisku and Buur (2007) argument that visual methods—such as video documentation and annotated imagery—can illuminate embodied practices and foster shared understanding in collaborative, tool-intensive settings like repair cafés. Integrating their insights, such as *'video stories'* and *'video portraits'*, can provide the importance of visual tools in capturing and conveying tacit knowledge within repair communities.

Collaborative Knowledge Ecosystems

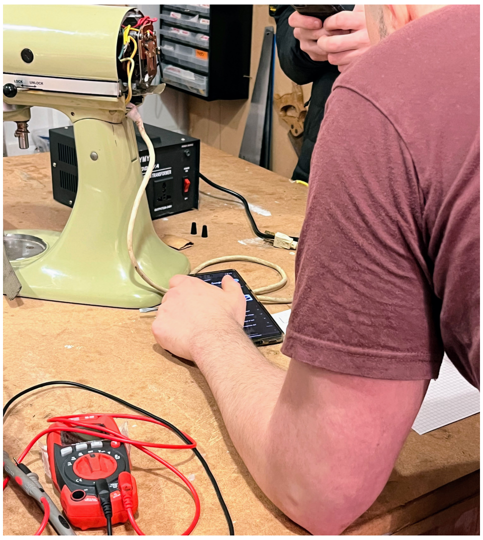
The community repair environments we studied function as what Wenger (1998) conceptualises as *"communities of practice"*—social learning systems where knowledge is collaboratively constructed and negotiated through participation in shared activities. Knowledge transfer occurs through apprenticeship relations, peer consultations, and collective problem-solving sessions that constitute a complex ecosystem of expertise distribution.

Participants' accounts, such as

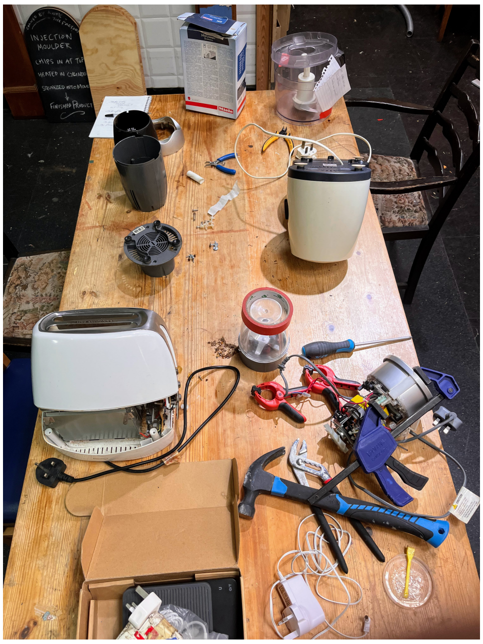
> "*They then have to pass that knowledge on to somebody else...There's always somebody else that comes in and helps out when you're stuck...*"

-illustrate Hutchins (1995)' concept of *"distributed cognition"*—cognitive processes that span multiple individuals and their material environment. Digital tools should thus incorporate real-time communication features and shared knowledge repositories, enabling repairers to contribute to a collective tacit knowledge database and benefit from cumulative community experience.

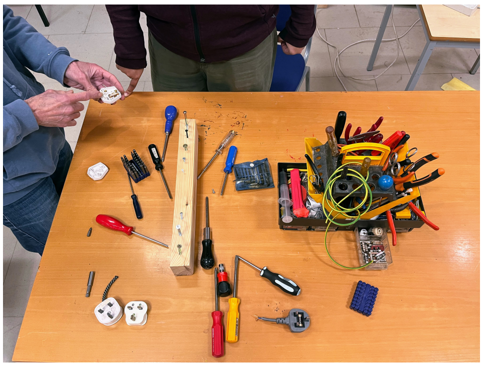
Design Implications: Tacit knowledge underpins the repair process, as repairers rely on hands-on, trial-and-error methods. Support tools should thus support in-situ documentation and real-time annotation to foster experiential learning. Adaptive troubleshooting—combining systematic diagnostics with intuitive improvisation—demands flexible tools for both structured guidance and open-ended exploration. Moreover, visual heuristics require features for visual capture, annotation, and augmented reality. Finally, because tacit knowledge circulates through social interaction, tools must enable real-time communication and shared repositories for collaborative knowledge exchange in repair communities.



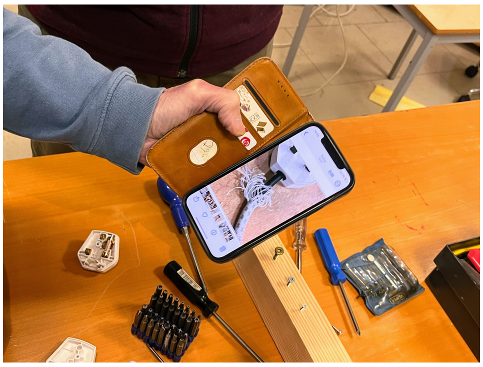
(a)
A repairer troubleshoots a kitchen appliance using prior experience and a digital reference.



(b)
A workspace filled with dismantled appliances, where repairers rely on trial and error to diagnose faults.



(c)
A repairer visually inspects a faulty plug, using pattern recognition to identify issues.



(d)
A repairer shares an image of a repair process on a phone to seek advice or verify a solution.

Figure 1: Repairers engaging in different repair strategies, including hands-on troubleshooting, trial-and-error diagnostics, visual pattern recognition, and collaborative knowledge sharing.

Conclusion & Future Work

This preliminary study emphasises the significance of tacit knowledge in community-based repair settings and lays groundwork for digital tools that capture and support such knowledge. However, how tacit knowledge evolves within individuals and groups over time remains underexamined, calling for longitudinal research on experiential expertise and recognition heuristics.

The contributions are two-fold. First, from an ethnomethodological perspective, this work highlights repair as an embodied practice integral to socio-technical dynamics. Second, it proposes design considerations for integrating digital tools, illustrating both complexities and possibilities of technological augmentation.

Future efforts will expand observations and interviews, supplemented by technology probes: (1) *In-Situ Documentation Access*, facilitating real-time reference during repair, and (2) *Automated Archiving of Repair Processes*, systematically capturing decision-making to build collective knowledge.

HCI research should thus explore how users construct and adapt mental models during breakdowns in collaborative, situated contexts. Viewing repair as social and relational, rather than purely technical, can inform more inclusive and resilient system designs across the technology lifecycle.

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