Repair as Design: A Study on Engineering Student Attitudes and Experiences in Electronics Repair

Esther Roorda, Emily Shilton, Sathish Gopalakrishnan

***Abstract*—Addressing the rapid increase in global e-waste production requires a shift towards electronics repair, which not only mitigates e-waste but also reduces the carbon footprint associated with manufacturing new devices. While Right to Repair legislation aims to push manufacturers to design for repairability, 'repairability' is multifaceted, encompassing technical, practical, and socio-behavioral aspects. This study examines the attitudes and experiences of engineering students towards electronics repair, revealing gaps in both practical skills and awareness of environmental implications of their work, and a general lack of 'repairabiliy' in existing consumer electronics. Despite their technical background, most students feel unprepared for repair and lack understanding of its environmental significance. The findings underscore the need for educational reforms that integrate repair skills and environmental literacy into engineering curricula to promote repairability in the design of personal electronics.**

I. Introduction

In 2019, approximately 53.6 million metric tons (Mt) of global e-waste was generated and this quantity is increasing at an approximate rate of almost 2 Mt per year [1]. A key way of addressing e-waste, and decreasing the embodied carbon required to manufacture new personal electronics is through electronics repair. Legislators have begun to address this problem through Right to Repair legislation [2], which requires, for example, for manufacturers to make spare parts and documentation available to the consumer. Beyond adherence to repairability legislation, some manufacturers prioritize repairability and modularity, integrating repairability into their design process and business model. 'Repairability' of personal electronics is not a straightforward metric however. Evaluating whether a product is genuinely 'repairable', and increasing this quality during the design process is a sociotechnical problem, requiring an understanding of the product's common modes of failure but also an understanding of how a typical consumer engages in repair, and the barriers they face.

Barriers to repair may be technical, practical and social or behavioural. In each of these respects, Electrical and Computer Engineering (ECE) students should be particularly well positioned to participate in electronics repair, ideally having the technical skills required to understand and fix electronics, access to tools and resources, an interest in electronics, and an understanding of the environmental harms associated with e-waste and electronic manufacturing. In this study we survey attitudes around repair in the ECE student population and observe that this is not the case. Engineering students often feel that they lack the practical and technical skills required to repair electronics, and don't understand how repair relates to environmental concerns. Consumers who do take an interest in electronic repair report that these skills and interests were developed outside of the context of formal education.

II. Background and Related Work

Existing work has investigated attitudes towards repair of personal electronics in the general population, showing that only a minority of consumers either engage in repair themselves or make use of professional repair services [3]–[5]. Cost and convenience are important drivers in consumer decision making [6]–[9], leading to a decrease in the popularity and availability of repair services as products become more complex and time consuming to repair [6], [9]. Research has also identified barriers to repair for both professionals and hobbyists, including lack of documentation, parts and tools, and disassembly difficulty [2], [8], [10]. Community repair initiatives and their challenges have also been studied in existing work [11]–[13], which has identified similar practical and technical barriers as major challenges, as well a shortage of diverse skilled volunteers. We do not know of existing work that has studied attitudes to repair of electrical and computer engineers specifically, or has discussed addressing barriers to repair through repair education at the university level.

III. Approach

We surveyed the Electrical and Computer Engineering (ECE) student population at the University of British Columbia. This survey was online and anonymous, and advertised to the whole ECE student population, approximately 1000 students in total, with 83 eligible respondents in total.

Through weekly repair workshops, held over the course of a four month semester, we observed a class of seven engineering students as they engaged in the repair of a variety of broken household electronics. We also observed experienced hobbyists performing repairs at a series of community repair events, and interviewed five experienced repairers.

IV. Outcomes

A. Technical Barriers Repair

Despite the majority of survey respondents having taken courses in electronics theory and hands-on electronics courses (77% and 73% respectively), and having at least moderate experience with soldering, using multimeters, oscilloscopes and power supplies, 44% of students reported that they had never tried to repair any piece of electronics themselves, and that they had little or no experience in repair. The most common barrier to repair reported by surveyed students was "not knowing where to start". At a lower level, skills like

applying epoxy or dealing with stripped screws are activities encountered regularly during repair, but not during their previous course work or design projects. This suggests that electronics repair is a separate skillset, with its own processes, strategies and tools, which can't be supplanted by theoretical understanding or experience designing electronics.

B. Practical Barriers to Repair

In line with the findings of existing work, many of the barriers to repair related to practical concerns. From least to most common, the five most common practical barriers to repair were safety concerns, time constraints, lack of documentation, access to tools and access to replacement parts. These issues, particularly access to tools and parts, were echoed by experienced repairers, who had in many cases built up extensive sets of tools and components over the course of many years, but were still frequently unable to repair electronics because they didn't have the required replacement parts. This was also a recurring theme in repair workshops, where missing tools (long handled screwdrivers, epoxy, oscilloscopes) or parts (fuses, power supplies, batteries) were common barriers to repair.

C. Behavioural Barriers to Repair

The prospect of disassembling complex electronics can be daunting with no experience or instruction, with concern around worsening the situation the second most commonly cited barrier to repair in our survey. In other cases, participants had little motivation to engage in repair themselves, describing cost, convenience and limited time as their main concerns: "it's easier to order something on Amazon then to waste hours tearing something apart". Among participants who did engage in repair however, the most common descriptor used to describe the repair was "fun", with several describing it as "exciting" or "rewarding", or even a "bonding" experience when done with family members. Experienced repair hobbyists echo this, describing their primary motivation for repairing their enjoyment of practicing repair, and a sense of accomplishment when something is fixed successfully. This suggests that approaching repair as a learning experience, and an inherently interesting and rewarding process may be more motivating than presenting it as a practical cost saving measure.

D. Repair as Eco-behaviour

75% of survey respondents reported that the environmental effects of electronic manufacturing and disposal had never been discussed in their academic classes, and while some had learned about this outside of the classroom, others reported that the survey was the first time they had heard of these concerns. This is reflected in their explanations of why they have not engaged in repair. Responses indicate a lack of knowledge about e-waste ("it's hard to know where all of my e-waste even goes", "I assumed that these electronics are almost fully recycled if taken to a depot."). In other cases, despite knowledge of the environmental effects, respondents report these effects as "massively outweighed by inconvenience" or "not my responsibility".

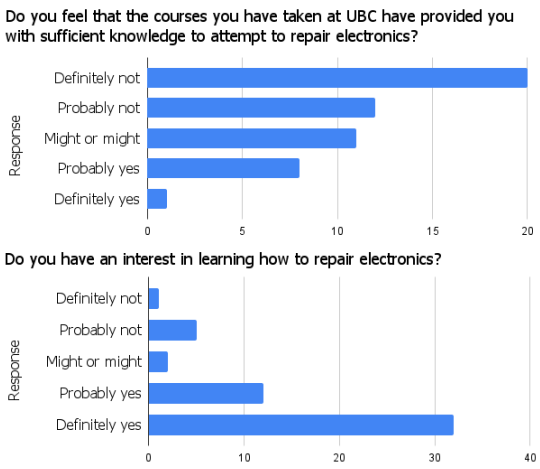

Fig. 1. Survey Responses on Repair Education Experience and Interest

E. Repair Education

As shown in Figure 1, the vast majority of respondents reported that university coursework had not prepared them to engage in repair. Encouragingly however, the vast majority also expressed interested in learning hands-on repair skills, with many respondents also adding that they would like to learn more about e-waste and the Right to Repair movement. The more skilled repairers interviewed reported developing their skills primarily through hands on practice and experimentation however, as opposed to in a traditional university setting. Several described learning from seeing the same problems and devices (toasters or kettles for instance) many times, and learning from peers at community events.

V. Conclusions and Future Work

The barriers faced even by knowledgeable and skilled students with an interest in computer engineering suggests that consumer electronics are decidedly not 'repairable'. Ideally engineers should prioritize, or at least consider, repairability during the design process, but our results suggest that these engineers are themselves unlikely to have any experience or understanding of electronic repair. We argue that education is a key part of increasing rates of repair: building environmental literacy and hands-on repair skills in the community encourages students to buy more repairable products and engage in repair, and teaching these subjects as part of the engineering curriculum provides engineers with a better understanding of how to design robust, repairable products. Our results suggest that to achieve the shifts in attitude and perspective required, non-traditional strategies for engineering education are necessary, emphasizing hands-on experience and community engagement, and promoting repair as an educational and environmental activity.

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