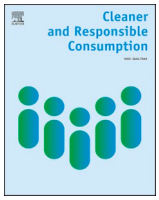
Cleaner and Responsible Consumption 12 (2024) 100174

Contents lists available at ScienceDirect

Cleaner and Responsible Consumption

journal homepage: www.journals.elsevier.com/cleaner-and-responsible-consumption



Overcoming Premature Smartphone Obsolescence amongst Young Adults

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ARTICLE INFO

Keywords:
sustainability
Behaviour Change
Installation Theory
Obsolescence
Activity
Smartphones

ABSTRACT

Rapid smartphone replacement contributes significantly to electronic waste issues. This paper investigates determinants of premature smartphone obsolescence amongst young adults and proposes psychology-based solutions to reduce associated sustainability impacts. Activity Theory maps replacement journeys to focus interventions on problem recognition. Grounded in contemporary Installation Theory, obsolescence drivers are analysed across physical affordances, embodied competencies and social regulations. Smartphone replacement journeys are mapped through Activity Theory to focus on problem recognition as an intervention point. Expert interviews and a user survey supplement literature in investigating obsolescence factors. Solutions are then structured along Installation Theory dimensions for a systemic approach targeting underlying barriers. Solutions address the three layers of behavioural determination. Smartphone modularity addresses physical issues, like repairability and upgrade. Consumer education campaigns improve competencies and perceptions, hereby fostering longer use. A "Slow Smartphone Movement" is proposed, leveraging social strategies, including pledges and online communities, to redefine cultural obsolescence narratives and address the positional aspects of having the latest generation smartphone. Together these multilayered interventions provide actionable pathways to prolonging lifespan by fundamentally reshaping psychological ownership patterns underlying premature smartphone disposal. Rather than isolated initiatives, these synergistic solutions provide specific, evidence-based pathways to fundamentally transforming entrenched obsolescence mindsets and behaviours amongst younger demographics. The paper concludes by outlining study limitations and stating that future research must empirically evaluate the proposed solutions.

The current paper investigates the determinants and consequences of premature smartphone obsolescence amongst young adults and proposes psychology-based solutions to reduce its detrimental environmental and societal impact. Activity Theory was used to define the research scope, ultimately focusing on the first stage in the buyer behaviour model, reflecting a prototypical customer journey along five consecutive decision stages. Problem recognition, essentially the perceived difference between the current and desired state of being, was subsequently analysed through the three interrelated layers of Installation Theory, physical affordances, embodied competencies, and social regulations. Eventually, potential solutions, grounded in academic literature, expert interviews, and a consumer survey, were organised along the three dimensions of installation theory, creating a holistic and effective strategy for tackling smartphone obsolescence. Smartphone modularity represents a promising starting point to address the problems associated with physical affordances, such as broken parts, worn batteries, and planned obsolescence more generally.

Additionally, extensive consumer education coupled with awareness campaigns highlighting the alternatives to purchasing new products and awareness campaigns highlighting the alternatives to purchasing new products could tackle issues associated with embodied competencies. Lastly, social regulations manifested partly in the universal need for belonging and social inclusion, represent the last driver of smartphone obsolescence. Virtual communities and reward schemes could further foster lasting normative change, eventually helping redefine the detrimental consumerism culture.

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https://doi.org/10.1016/j.clrc.2024.100174
Received 15 July 2023; Received in revised form 13 January 2024; Accepted 19 January 2024
Available online 6 February 2024

1. Introduction

Produce, buy, throw away, the linear economy has shown its limits in terms of impacts on living beings (depletion of natural resources; large volume of waste, various types of pollution; impacts of industrial activities on biodiversity and on human beings), on companies by forcing them to innovate to create growth in turnover continuously; and finally, on consumers by causing frustrations or even instigating symbolic violence between those who can and those who cannot buy/afford (Guillard et al., 2023). Smartphones represent a rapidly growing e-waste stream, with premature obsolescence a major contributor (Singh et al., 2020). Short lifespans increase disposal and exacerbate sustainability issues in manufacturing and resource extraction (Suckling and Lee, 2015). Despite the ability for 5-year use, average retention falls below two years (Benton et al., 2015), especially among younger demographics (Proske and Jaeger-Erben, 2019). This highlights the need for solutions targeting obsolescence. Rising smartphone adoption has exacerbated sustainability issues associated with short lifecycles and premature obsolescence (Benton et al., 2015). Frequent upgrading carries significant climate impacts, with 70–80% of emissions occurring during resource-intensive manufacturing (Andrae and Edler, 2019). This highlights the need to prolong the lifespan of smartphones. However, practical solutions grounded in psychological theory remain limited.

With growing populations, rising incomes, and increasing urbanisation, solid waste is gradually becoming a major environmental, social, and economic problem (e.g., Hoornweg and Bhada-Tata, 2012; Wilson et al., 2015). In this context, the fastest-growing waste stream, e-waste (United Nations University, 2017), is associated with particularly severe environmental (e.g., Robinson, 2009) and socio-economic (e.g., Magalini, 2016) consequences. With global annual smartphone sales tripling since 2011 (Gartner, 2020), smartphones represent an increasingly large share of e-waste (Singh et al., 2020). Obsolescence, "the process or fact of becoming old-fashioned and no longer useful" (Cambridge Dictionary, n.d.), and the associated premature replacement of smartphones, especially among younger users who replace their phones the most (Proske and Jaeger-Erben, 2019), have been identified as a significant contributor to this detrimental increase.

To address this issue, the current paper investigates the determinants and consequences of premature smartphone obsolescence among young adults and then proposes psychology-based solutions to reduce its detrimental environmental and societal impact. An analysis of the user cycle with Activity Theory, following the prototypical customer journey along five consecutive decision stages, led us to focus on the first stage in the buyer behaviour model. Problem recognition, essentially the perceived difference between the current and desired state of being, is subsequently analysed through the three interrelated layers of Installation Theory before deriving practical solutions to address premature smartphone obsolescence amongst young adults.

Obsolescence determinants are analysed through the Installation Theory lens (Lahlou, 2017) across physical, competence and social dimensions to illuminate phone replacement journeys. Literature and professional insights identify key obstacles around repairability, negative ownership perceptions and cultural pressures. Tailored solutions are then structured along Installation Theory dimensions to target underlying drivers.

This research explores novel applications of contemporary socio-behavioural frameworks to technology ownership by bridging perspectives from sustainable engineering and social psychology. Following the literature review, this paper details the analysis, solutions and limitations.

2. The Problem

Product obsolescence poses significant environmental and social challenges worldwide. This term refers to the state of being outdated or no longer in use, and it can denote products or technology that are no longer relevant or useful in the current context (Stańczyk et al., 2021). The rapid acceleration of consumerism, often referred to as the "Throw-Away Society," has serious consequences (Sierra-Fontalvo et al., 2023). Prior research identified multiple drivers of premature smartphone replacement. Technical issues like battery deterioration or software incompatibility render devices unusable (Wieser and Tröger, 2015). Planned obsolescence practices also intentionally limit lifespan through unrepairable designs (Proske et al., 2016). Moreover, low-quality expectations and status motivations encourage faster upgrades (Abeele and Roe, 2013). These complex factors span physical, social and psychological elements. Smartphones' rapid growth has also exacerbated premature obsolescence and electronic waste issues. Global smartphone subscriptions reach 6.6 billion, with sales tripling since 2011 to over 1.5 billion yearly (Ericsson, 2022). However, the average lifespan remains extremely short. Smartphones used in the UK and the US last around 22 months, far below the technical potential of 5 years (Benton et al., 2015). With such high disposal rates, phones represent a fast-expanding e-waste stream, which is expected to reach 125 million tons by 2030 (Mahmud and Osman, 2021). This carries significant sustainability impacts, as manufacturing accounts for up to 80% of a smartphone's lifetime emissions (Andrae and Edler, 2019). Repair and reuse have thus gained interest for prolonging lifespan.

Moreover, among the various drivers of premature smartphone obsolescence identified in the literature, frequent operating system and application updates have been recognised to cause software incompatibility issues that render older devices unusable (Mengaldo et al., 2022). Hardware also deteriorates, with declining battery life, cracked screens or other damage triggering replacement (McMahon and Pope, 2019). Moreover, changing phone aesthetics and styles fuel perceived obsolescence, the feeling that current devices are outdated (Wieser and Tröger, 2015) . Manufacturers contribute through intentionally limited lifespans or restrictive repair policies to spur faster upgrades (Proske and Jaeger-Erben, 2019).

Psychological drivers are equally important, especially among youth demographics, which tend to replace phones more frequently (Bihouix and Guillebon, 2010). Status motivations create peer pressure to keep up with trends and signal identity, which can manifest in excessive materialism or conspicuous consumption (Barros and Dimla, 2021). Young adults also have low expectations for smartphone longevity and quality, limiting motivation for proper maintenance (Wieser, 2016). Existing research demonstrates that obsolescence has complex systemic drivers spanning technical issues, social pressures and psychological elements.

Although most purchase decisions for durable goods are replacement decisions, paradoxically, replacement purchases have received relatively little attention in marketing research. Instead, the research has concentrated on first purchases, principally concerning adopting innovations and new product categories (Guillard et al., 2023). As for digital technologies, while their environmental impact is steadily growing (Freitag et al., 2021), few studies analyse all the mechanisms at play in their obsolescence through their lifespan (Nano, 2023). Moreover, responses often remain fragmented rather than systemically addressing root causes across user practices, culture and business models. Modular or repairable phone designs target physical durability but overlook behavioural change (McMahon and Pope, 2019). Though valuable, such isolated approaches are likely insufficient to transform entrenched psychological patterns underlying premature obsolescence across critical demographics. Wieser concludes that "looking at the user is important if we want to address the actual use time of devices" beyond just their technical lifetimes (Wieser, 2016, p.58) . This suggests the need for contemporary psychological perspectives tailored to young consumers' perceptions and social context.

Moreover, in a capitalist, profit-oriented market economy, producing highly durable products will eventually fail (e.g., Mankiw, 2014). Manufacturers that adequately satisfy the needs of their consumers will ultimately be driven out of business for lack of revenue and profitability - unless they win new customers or conquer new markets (Homburg

et al., 2013). The infamous Phoebus Cartel in the 1920s provides an excellent account of how competing manufacturers intentionally joined forces to engineer shorter-lived lightbulbs to maintain revenue and profit growth (e.g., Sasaki and Strausz, 2008; Krajewski, 2014). To this day, lightbulbs are expected to last only a couple of years, which seems ironic given that the illustrious Centennial Bulb has burned almost uninterruptedly since 1901 (e.g., MacIsaac et al., 1999; Hadhazy, 2016). Unsurprisingly, then, manufacturers across industries started to reduce the lifespan of their products to uphold demand deliberately and, as a consequence, profitability. This process of intentionally short product life cycles, often dubbed planned obsolescence, is particularly severe in monopolies and oligopolies where consumer scrutiny and power are severely limited (Bulow, 1986).

However, this dramatic form of demand generation only marked the advent of consumerism that has since followed. Like the lightbulb manufacturers in the 1920s, car companies, just before the great depression, saw themselves confronted with nearing market saturation (e.g., Sloan, 1990). Ford's Model T, arguably the most popular and robust car at the time, was so dependable that Ford, just as any other company, had trouble selling cars once people owned a Ford. In response, General Motors (GM) developed an ingenious sales strategy that eventually supercharged GM's rise to the industry's top (Sloan, 1990). Instead of building just one type of car that remained unchanged until technological innovation necessitated new constructions, GM designed and produced annually changing models (Sloan, 1990). By promoting the possession of the latest version of any given product, companies actively spurred social comparison and the desire to differentiate positively from one's peers. Social status, for millennia, a fixed and inherent component of hominids (e.g., De Waal and Waal, 2007), now manifests itself in material possession (e.g., Belk, 1988). Novel model designs and the accompanying product variety further allow people to express their personality and identity through the products they purchase and possess (e.g., Belk, 1988). Although intensely promoted by emerging marketing men (e.g., Bridgens et al., 2017, p. 169), consumers soon started to perceive their current devices as outdated. This phenomenon is now known as perceived obsolescence.

Thus, planned and perceived obsolescence represents a vivid reflection of the prevalent throwaway culture (Cooper, 2005), rooted in companies' efforts to maintain profitability but equally influenced by consumer demand and taste. Governments even promote obsolescence to boost economic performance by increasing consumer spending (London, 1932). Indeed, the current economic system is constructed around continuous consumption, which eventually is needed to fuel the ever-more demanding capitalist system (e.g., Lobos and Babbitt, 2013).

The same pattern is readily observable in the realm of electronic devices, smartphones in particular (Hanks et al., 2008). While all stakeholders, except for the consumer, are expected to have a direct and augmented interest in the acceleration of obsolescence for profitability's sake, consumers also contribute their share to the problem of premature product replacements.

Like retailers and mobile service providers that earn a commission by distributing smartphones, manufacturers naturally desire to sell the most possible devices. Yet, even companies that allegedly fight consumerism, such as refurbishers, benefit from rapid smartphone turnovers. In contrast, consumers theoretically gain from keeping their existing phones as long as possible. In reality, however, they routinely decide to replace their phones prematurely, a behaviour often at odds with the rational conception of homo economicus (e.g., Mankiw, 2014). For example, while experts estimate the potential life to be around five years, the average lifespan for mobile phones in the US and UK, for instance, falls just short of two years (Benton et al., 2015). Illustrating such a cycle, one of our interviewees explained that "as a consumer, you are kind of trapped in the system of replacement." – Interviewee 2.

Furthermore, despite the rapidly growing second-hand market (e.g., Deloitte, 2016), most consumers who opt for a new phone still hold on to their old device, which inevitably results in a vicious cycle that permanently requires new products and endangers natural resources, particularly raw earth elements (e.g., Bookhagen et al., 2020). The subsequent accumulated demand for smartphones has detrimental environmental and social consequences. While the manufacturing process and preceding resource extraction have severe ecological impacts, accounting for an estimated 74% of smartphones' lifetime greenhouse gas emissions (Suckling and Lee, 2015), a poorly designed end-of-life strategy proves equally harmful (e.g., Chapman, 2017), with roughly 90% of the smartphones discharged on landfills without some recycling (Mitchell and Morgan, 2015) . On top of the staggering environmental costs, excessive smartphone production, driven by premature obsolescence, comes with a heavy social price tag. While the benefits of novel devices are harnessed primarily in industrialised nations, the costs are almost exclusively borne by developing countries, further contributing to the existing development gap between rich and poor countries (e.g., Alvaredo et al., 2017). Nnorom and Osibanjo (2008), for instance, demonstrate how inadequate waste management infrastructures and extended producer responsibility legislations in developed countries contribute to the 'digital divide', effectively forcing people in developing countries to burn, bury or dump electronic waste in highly polluting and sanitary harmful ways (Vaccaro et al., 2015).

Longer product lifetimes and well-designed end-of-life strategies are widely considered effective solutions for reducing electronic waste (e-waste) (e.g., Wilhelm, 2012). Yet, any attempt to tackle premature smartphone replacements requires a thorough and holistic problem analysis, which considers all direct and indirect drivers of smartphone obsolescence. Viable solutions must ultimately bridge the competing interests among all stakeholders. Moreover, while prior studies examine obsolescence determinants, practical interventions grounded in theory are lacking (Wieser, 2016). Existing responses also lack a systemic perspective connecting drivers to tailored solutions across technical, user and social dimensions. This research gap constrains efforts to prolong smartphone lifespan among key demographics. This paper asks: How can smartphone obsolescence be reduced through psychology-based solutions targeting young adults?

To answer this question, consumer replacement journeys are analysed using the contemporary Installation Theory framework (Lahlou, 2017), and implemented through Multilayered Installation Design method (Lahlou et al., 2022). This systemic approach illuminates specific pathways for intervention by comprehensively assessing obsolescence drivers across physical affordances, embodied competencies and social regulations. The method used examines the consumer journey step by step to spot the orientation/decision moments and the components that shape the decision, in the three layers of installation theory. Professional interviews and a small quantitative user survey also inform and evaluate proposed solutions. In summary, this paper's unique angle is applying Installation Theory to illustrate a multidimensional strategy.

The following sections map smartphone replacement journeys using Activity Theory (Nosulenko et al., 2005) and elucidate problem drivers through Installation Theory's multidimensional lens and by using the Multilayered Installation Design (MID) method. Tailored solutions grounded in behavioural change theories and mechanisms seek to overcome identified barriers among young demographics. Finally, study limitations and conclusions summarise key insights while proposing future research directions to evaluate the interventions empirically.

3. Methodology

This paper employs a mixed methods approach spanning literature review, desk research, professional interviews, and a user survey to investigate smartphone obsolescence determinants and solution pathways. Embodied in contemporary Installation Theory (Lahlou, 2017), the multilayered analysis targets root causes across physical, competence, and social dimensions to enable systemic interventions.

In practice, following the literature review (see Section 2), the mechanisms and factors identified in desk research (extracting the

operational factors from the academic and grey literatures) were fed into the Multilayered Installation Design method (MID, Lahlou et al., 2022.) which seeks to identify the intervention points along the user's activity trajectory, and at each point consider the factors, mechanisms and possible levers for change. The user's trajectory is analysed using two frameworks, one temporal (Activity Theory) and the other one situational (Installation Theory).

At its core, Activity Theory describes how individuals or collective agents seek to accomplish their goals and satisfy underlying motives through a series of activities and subgoal accomplishments. The distinction between activity and behaviour is that the former describes "what subjects do, experienced from their own perspective", whereas the latter is "what subjects do, as described from the outside by an external observer" (Lahlou, 2017, p. 346). Activity Theory understands human activity as a goal-directed trajectory from a given status quo to a consciously represented future state (goal). Attainment of the goal is driven by the internal motives of the individual that reach satisfaction once the desired state is reached and typically passes through several subgoals that are achieved incrementally. Notably, a motive can be satisfied by several goals, and a goal can satisfy multiple motives. Throughout the process, contextual factors and external conditions shape the agent's specific behaviour. This conceptualisation of activity is highly subject-centric and focuses on the individual perception and experience of action (Lahlou et al., 2022). Using activity theory enables breaking down the trajectory into chunks that each have decision points (subgoals) and motives, and these decision points are potential points for intervention.

At each point, decision and action are influenced by a complex series of situational and dispositional factors.

Installation theory provides an operational framework to analyse this situational tensor, and a convenient structure to suggest potential levers or mechanisms of intervention. The first layer of Installation Theory plays an essential role in technological obsolescence by enabling and constraining physical smartphone usage. Physical affordances comprise all objective conditions constituting the built environment, ultimately guiding people's behaviour in a given context (Lahlou, 2017). According to this view, material objects can take on multiple roles, thus channelling people's activities through specific installations. They serve, for instance, as barriers, scaffolds, or trigger points for physical interactions. Accompanied with physical affordances, the second layer of the theory, embodied competencies, are paramount in executing behavioural sequences, effectively reducing the possible behaviour choices provided by physical affordances. In other words, not everything physically possible will eventually be realised. Therefore, understanding the concept of obsolescence requires carefully considering the essential protagonist, the user, who responds to physical affordances provided by the smartphone (Lahlou, 2017). Wieser (2016, p. 157) explained that "psychological and behavioural manifestations of smartphone replacement may lie deep within human psychology and are partially determined by the perception of an obsolete smartphone". Therefore, it is necessary to couple analyses of physical aspects with in-depth investigations of users and their preferences. Finally, the third layer, social regulations, ensures that behaviour is socially appropriate. Communities, organisations, and institutions can be involved in social regulation. In the context of smartphone obsolescence, these (unofficial) codes can consist of rules, social norms, rewards, etc. and contribute to when and why smartphone users consider their devices obsolete. It is important to note that social regulatory processes can take on three forms: direct feedback from others, internalised standards within the individual, and "anonymous devices or signs" (Lahlou, 2017, p. 114). For smartphone obsolescence, a combination of all these forms is relevant and manifests itself first and foremost in the form of (a) peer influence and social norms and (b) status and roles. Installation Theory provides a holistic framework to analyse human behaviour that incorporates psychological and sociological perspectives, thus overcoming limitations associated with purely psychological theories (e.g., Ajzen, 1991) or purely sociological ones (e.g., Durkheim, 1982/1982). At the most fundamental level, Installation Theory explains and, to a certain extent, predicts behaviour through the interplay of physical affordances in the material world, agents' embodied competencies, and social regulations. However, as a macro-level framework, Installation Theory must be complemented with more nuanced concepts to understand a specific activity fully. Accordingly, Installation Theory is the overarching framework, supplemented with more detailed concepts for each layer. More specifically, we analyse the underlying drivers of smartphone obsolescence along the three layers. Activity Theory (Nosulenko et al., 2005) is utilised to trace the individual journey of stakeholders in their practices, identify potential issues, and define the scope of the proposed solutions. Installation Theory is then used as an analytical framework to offer a comprehensive understanding of smartphone replacement behaviour and identify real-world practical solutions, and propose behavioural change interventions (Lahlou, 2017). These two frameworks are applied to the current state of the offer as is available in 2023 in big European cities.

The paper thus applied the Multilayered Installation-Design to analyse the consumer journeys that lead to premature smartphone obsolescence and develop the proposed interventions. The below subsections explain additional methods which were employed to feed into the analysis.

3.1. Desk research

An initial review of the literature established theoretical grounding and synthesised prior evidence on obsolescence drivers. Emphasis was placed on studies utilising socio-psychological perspectives anchored in contemporary frameworks like Activity Theory (Nosulenko et al., 2005) or social practice theory (Jaeger-Erben & Silverthorn, 2021). Key mechanisms identified included cultural pressures, negative ownership perceptions, status motivations and changing technical requirements (Abeele and Roe, 2013; Wieser and Tröger, 2015). The literature analysis reviewed 52 scholarly articles focused specifically on consumer electronics ownership, usage behaviors, and obsolescence determinants published within the last 10 years. Articles were systematically searched across major databases including PsychINFO, Academic Search Complete, and Business Source Complete using relevant keywords. Initial screening of title, keywords, and abstracts narrowed results, then full text review confirmed final sample meeting inclusion criteria of 1) peer reviewed papers 2) prominently featuring psychological and/or sociological analysis of electronics ownership or replacement 3) published 2013-present.

The final sample focused predominantly on European contexts aligned with the target population. Qualitative synthesis employed a collaborative coding approach with peer debriefing to mitigate bias and derive key mechanisms including social pressures, changing skill sets and needs, among other techno-social antecedents to premature smartphone obsolescence.

3.2. Expert interviews

To supplement academic insights, semi-structured interviews averaging 30 min were conducted with five senior staff from leading European electronics reselling and refurbishing companies based on convenience sampling. Participants represented roles in procurement, supply chain logistics, device testing/grading, and business development. This expertise enabled first-hand accounts of end-user behaviours during the return, exchange, and upgrade process. Questions directly inquired about factors driving consumer replacement decisions from this vantage point as well as larger industry trends contributing to smartphone obsolescence rates based on aggregate data. Responses were transcribed verbatim and analysed using thematic analysis aligned with the conceptual framework. Specific, detailed examples from the interviews are incorporated in section 4, findings.

Questions elicited perspectives on obsolescence determinants based on frontline consumer experiences and solution viability assessments.

Interview analysis employed protocol coding around emerging themes aligned with Installation Theory dimensions (Lahlou, 2017). Interviews were transcribed to be coded with manually, through transcribing only verbal utterances byusing Braun and Clarke's (2013, p. 166) notation system. To avoid changes in meaning, the raw data was edited as little as possible (Braun and Clarke, 2013, pp. 162–165). This also includes punctuation. This stage aimed to ground truth findings in applied settings while gathering judged input on intervention feasibility.

3.3. User survey

A small-scale survey (see Appendix D) evaluated literature themes, assessed consumer perceptions, and examined intervention preferences applying Installation Theory structure. Descriptive statistics measured agreement levels across obsolescence factors and potential solutions. Open-ended questions elicited additional qualitative insights into replacement rationale and experiences. Together, these methods enabled data and methodological triangulation for rigour (Guion et al., 2011). The survey was administered after obtaining ethics approval from the London School of Economics and Political Science research ethics review board. At the beginning of the online survey, participants were presented with an informed consent form (see Appendix D) stating the anonymous nature of the study and that data would only be analysed in aggregate for research purposes. Participants indicated consent by clicking 'Next' before accessing the full survey. The consent form notified participants of their rights, including the ability to withdraw at any point during the survey, and provided contact information if they had questions or concerns. No personal identifying information was collected from participants. All survey responses were anonymous, and confidentiality was protected by storing data on secure servers, accessible only to the research team.

The survey was administered to 147 smartphone owners meeting specified inclusion criteria via social media recruitment. Screening ensured respondents matched the target demographic (18–29 years old) and geographic area (metropolitan areas in the UK/EU) given cultural/context dependencies in consumption patterns. The final sample size meeting all criteria was 122 complete, valid responses. The survey included closed and open-ended items adapted from existing measures on obsolescence determinants, technology usage, ownership perceptions, and demographic variables. Descriptive, correlational, and inferential analyses were computed in SPSS with statistical significance threshold set at $p < 0.05$.

Qualitative data from the open-ended questions was coded inductively, then integrated with quantitative findings to provide rich mixed insights. Details on the sampling procedure, precise inclusion/exclusion criteria, and descriptive sample statistics are presented in Section 4 alongside specific results. The goal of this small survey is merely to check if the factors spotted in the consumer journey by the other methods (desk research, expert interviews) are indeed important, and, through the open-ended questions, whether some important factors have been missed. Hence no sophisticated model is tested in this survey; the main result is to provide an order of magnitude or importance of the various factors.

The results synthesise evidence from these three stages to identify salient techno-social drivers within each Installation Theory dimension. Tailored solutions are then derived by targeting revealed barriers and mechanisms, with professional and user assessments further refining practical viability. This empirical grounding and contemporary psychological framing aim to advance academic applications while producing actionable, systemic pathways to combating smartphone obsolescence.

Overall, the multi-method design allowed for solid triangulation across literature themes, industry perspectives from supply-side experts, and demand-side factors directly from consumers. Together these complementary techniques ensure comprehensive, empirical-based identification of obsolescence drivers.

4. Results and discussion

4.1. Stages of decision

While smartphone obsolescence is a complex and multidimensional process, influenced by distinct stakeholders across several stages (e.g., Proske and Jaeger-Erben, 2019), the final authority largely lies with the end customer (Guiltinan, 2009), whose behaviour and motivation represent an optimal starting point to investigate premature smartphone renewal. Though multiple approaches are conceivable to examine and analyse consumers' untimely smartphone replacements, Nosulenko and colleagues' (2005) interpretation of Activity Theory seems particularly useful given its seamless integration of subject orientation and consideration of contextual factors into a holistic framework. In this sense, Activity Theory allows us to dissect broader behaviour patterns into more fine-grained, goal-oriented sequences (Lahlou, 2017, p. 62).

Regarding smartphone replacement, Activity Theory can be conceptualised along Howard and Sheth's framework of buyer behaviour (1969) , spanning from problem/need recognition to post-purchase behaviour (see Fig. 1). In the first stage of his process, consumers recognise a need/problem and subsequently seek to meet that particular need through specific actions. In this vein, the intention to replace one's current smartphone with a newer model represents the desired goal to satisfy some underlying motive that arose in the first stage of the buyer behaviour model. The subsequent phases in the buyer behaviour model represent concrete activities and subgoals needed to achieve the overarching goal – eventually acquiring a new smartphone.

While all five stages of the buyer behaviour model deserve a more detailed elaboration, our exploratory interviews with users and refurbishing experts followed by a small-scale confirmatory survey ($N = 122$) revealed and identified the first stage, problem recognition, as the most promising to investigate and understand premature smartphone replacement, thus, being the focus of this paper As shown in Fig. 2, approximately %70 of our respondents' indicated that their decision to replace their smartphone is mostly due to software issues. Similarly, around %51 have indicated that the decision is taken due to a physical defect.

Indeed, if we can avoid the consumer engaging in a search for a new smartphone and be satisfied with, e.g., only a minor upgrade of her current product, the problem is nipped in the bud. The emphasis on problem recognition in the smartphone replacement process allows a frictionless analysis of the underlying needs along the three dimensions of Installation Theory. Ultimately, a person's perceived need for a new smartphone is shaped by physical affordances, embodied competencies, and social regulations. Each layer influences and contributes to the perceived difference between the actual and desired state of being, eventually channelling consumers to the subsequent step in the buying process, the information search.

4.2. Understanding and addressing premature obsolescence

Table 1 lists the main issues identified using Installation theory: physical dysfunction, replacement obstruction and repair costs, technological advancements, lack of embodied skills to replace dysfunctional components for modular smartphones, lack of awareness of the necessity for prolonged smartphone usage, social signalling, and environmentally detrimental social norms. The challenges identified in each layer were further condensed and analysed for feasibility by creating an addressability versus impact matrix (see Fig. 3) to identify the most promising and likely areas more concretely for improvement. Consequently, practical solutions were derived to overcome the identified problems (see Fig. 4, Table 1).

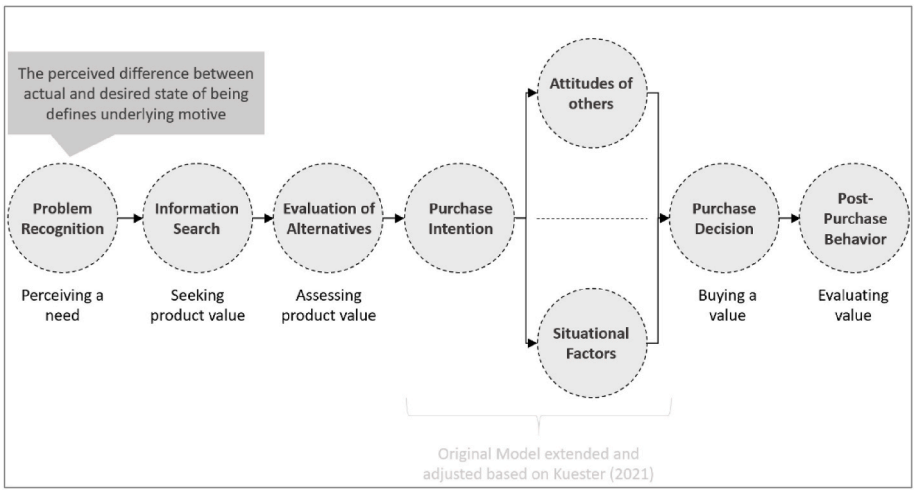

Fig. 1. Adaption of Howard and Sheth's (1969) buyer behaviour model.

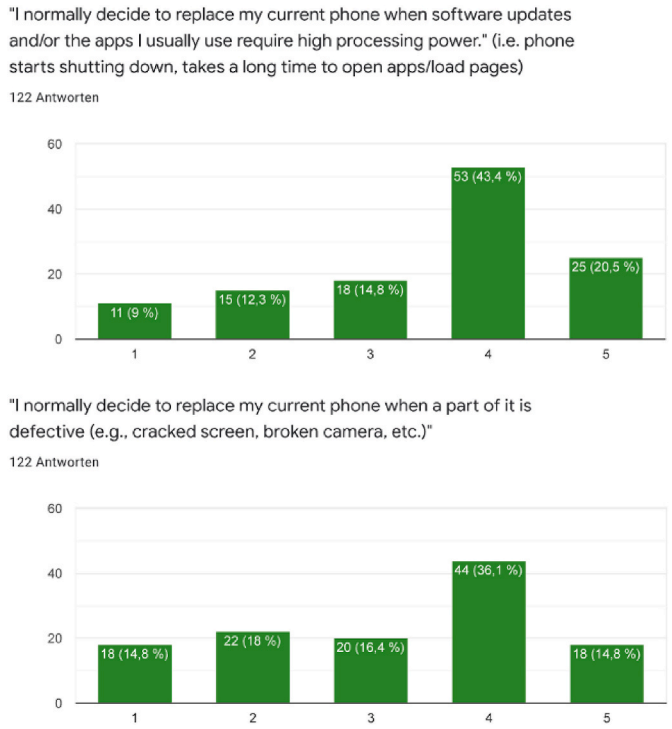

Fig. 2. Results from small-scaled survey illustrating that respondants decision to purchase a replacement smartphone mostly occurs when a software and/or hardware problem is perceived.

4.2.1. Physical affordances – Properties of the environment

4.2.1.1. The problem. Several studies have investigated the determinants of premature smartphone replacement, frequently reporting that physical and built affordances represent one of the main drivers (Proske and Jaeger-Erben, 2019). Dysfunctional batteries, broken screens, and cameras that cannot be replaced efficiently represent common manifestations of physical shortcomings in smartphones. According to our consumer survey, more than 50% of people cited this as a reason for replacing their phones prematurely. Similarly, common consumer experiences include the unavailability of replacement components and excessive repair costs (Jaeger-Erben et al., 2021), mirroring the 60% of our survey respondents prefer buying a new phone rather than having it repaired. Technological advancements further accelerate premature smartphone replacement as older devices often lack the processing power required to run the latest operating systems and apps (Proske et al., 2016). Upon conducting a small-scaled confirmatory survey, around 65% reported this as their reason for buying a new phone (see Appendix A).

Moreover, physical damage was also highlighted in our interviews as one of the main reasons for people to consider replacing their smartphones: "[…] few devices are returned or handed in with damages. We see that one factor is that people have issues with their device [is that], for instance, the screen is broken, so what do I do? Do I send it in for repair? Or do I buy a new one? This certainly is a factor [for premature smartphone replacement]."

For smartphone obsolescence, physical affordances constitute the technological and physical aspects constructed by various stakeholders, such as smartphone design and sales promotions, which deliberately promote premature product replacements. This process is known as planned obsolescence (Podoshen and Andrzejewski, 2012). Smartphone producers, software developers, hardware suppliers, mobile service providers, and smartphone retailers (Arvind, 2009) represent the key stakeholders (Freeman, 1984) that intentionally propagate this cycle of obsolescence by crafting physical aspects of smartphones for limited repair, limited functional life, reduced aesthetics, cyclicality and restricted technological updates (Fassin, 2009; Satyro et al., 2018). Ultimately, these stakeholders seek to stimulate the linear economy to ensure high sales volumes, growth, and profitability (Guiltinan, 2009)..

4.2.1.2. The solution. The key to addressing the physical aspects of smartphone obsolescence amongst young adults thus lies in a design that allows for continuous functional durability and material quality. In line with this, we suggest the concept of modularity to address the physical constraints of smartphone repair.

Modularity is the extent to which a system's components can be separated and/or recombined to increase durability and flexibility (Baldwin and Clark, 2000). Individual components can be exchanged without having to replace the entire product. Most importantly, however, modular devices are easily upgradable. Thus, in the context of ongoing technological advances, modular designs allow for physical upgrades such as more storage, better cameras, and software upgrades (Schischke et al., 2016). Furthermore, modularity also enables individual customisation through adapting functionality. Thus, depending on the aspects of the phone that are most important to an individual, these can be made more prominent (Hankammer et al., 2018). For example, if an individual needs a longer-lasting battery, they can install a larger battery pack. Moreover, our survey revealed that one of the main barriers to repairing second-hand phones is their worry about repair quality

Table 1
Overview of the significant challenges and proposed solutions identified in this paper

Layer of Analysis	Prioritised Challenges	Recommendation	Implementation
Material Affordances (Smartphone)	Physical dysfunction Replacement obstruction & repair costs Technological advancements	An alternative design that allows for continuous functional durability and material quality	Modular design for smartphone which enables replacement of dysfunctional parts and components (e.g., Fairphone)
Embodies Competencies (User)	Lack of embodied skills to replace dysfunctional components for modular smartphones	Effective transmission of the necessary and empowering knowledge, skills, and competencies to the user	Educative "How to …" videos and clips recorded from first person perspective using glasses with small cameras planted at the eye-level (e.g., subcams (Lahlou et al., 2015)
	Lack of awareness on the necessity for prolonged smartphone usage	Increasing consumer awareness and providing smartphone users with the necessary information and skills (improving decision-making competencies through techniques such as Boosting (Hertwig and Grüne-Yanoff, 2017) to foster sustainable decision making through campaigns which focus on harmful environmental impacts of premature obsolescence	Graphic visualisations Environmental messages framed in terms of gains and losses (with an emphasis on losses) Proper use of social media to enhance accessibility
Social Regulation (Institutions)	Social signalling	A social movement to revert the norms of smartphone obsolescence with instilling a sense of community	The "Slow Smartphone Movement" Online accounts with profile pictures that indicate through specific frames or colours how long a person has kept their smartphone
	Environmentally detrimental social norms	Dynamic social norms (drawing attention to how more people are changing their behaviour towards sustainable consumption patterns (Sparkman and Walton, 2017)) Promote "Slow" smartphone consumer behaviour	*"Over the past two years, X% have started to keep their current smartphone for more than 4 years. Help grow the movement!"* Utilising social media influencers to normalises prolonged smartphone usage

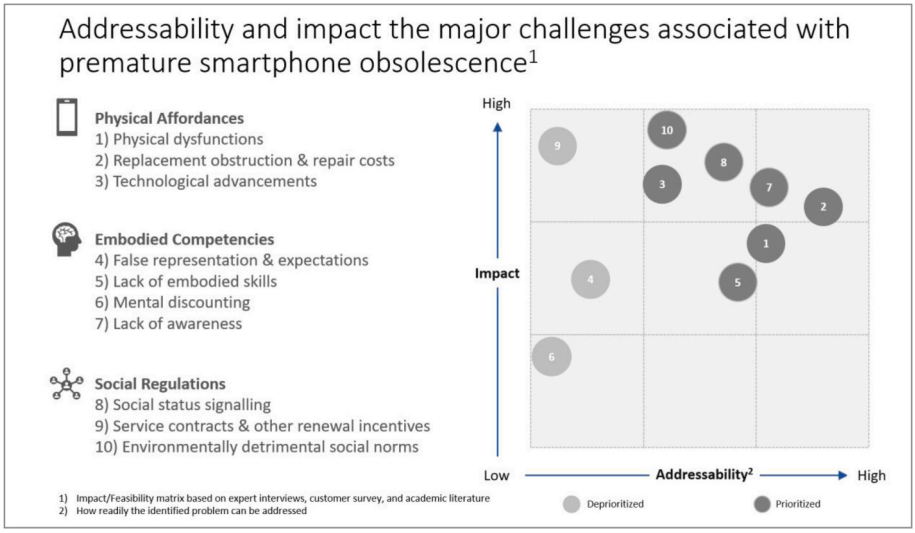

Fig. 3. -Addressability/Impact Matrix: Identifying the most relevant challenges associated with smartphone obsolescence.

Approximately %60 of our respondants agreed with purchasing a new smartphone being less costly than having it repaired (see Fig. 5).

However, modularity directly addresses this issue by allowing one to replace these parts. Modular smartphones have existed for several years but have only recently gained popularity. Owning such a device will make it easier to repair and customise your phone and act as a form of social signalling. Signalling theory posits that individuals acquire items as a manifestation of symbolic capital through which they can signal to others their values and status (Bird and Smith, 2005). In this sense, owning a modular smartphone will signal to others their pro-socialness and environmental values (Glazer and Konrad, 1996; Johnson et al., 2018), which is increasingly relevant with the growing movement towards sustainability. Secondly, the customisation of modular devices allows for personalised instruments, building on the idea of extended self (Belk, 2013), whereby possessions are regarded as a part of an individual's identity through the attachment and construction of meaning and experiences. The repairability of modular devices complements this notion. Individuals are enabled to rapidly and seamlessly replace parts themselves. The individual is consequently empowered to build and mend actions that would otherwise be outsourced and not experienced by the smartphone owner (Lockton, 2013), further fostering an emotional bond and meaningful relationship with one's smartphone (Cushing, 2011). All these experiences increase the smartphone's lifetime and counter the obsolescence culture.

The user survey and interviews revealed physical smartphone damage as the most common obsolescence trigger, yet high costs and complexity deterred repair. As Interviewee 1 indicated, "When screens crack, people often just buy new phones." Modular designs have recently gained traction by enabling more straightforward part replacements, but broader consumer adoption barriers persist. Survey feedback showed that pricing remained prohibitive for many younger buyers. This aligns with the literature emphasising device lifetime extensions through modular upgradability and customisation by reducing physical obsolescence factors (Proske et al., 2016) . Our industry experts also noted that modular phones' flexibility better meets diverse user needs. Enabling component swapping to improve battery life or storage marries

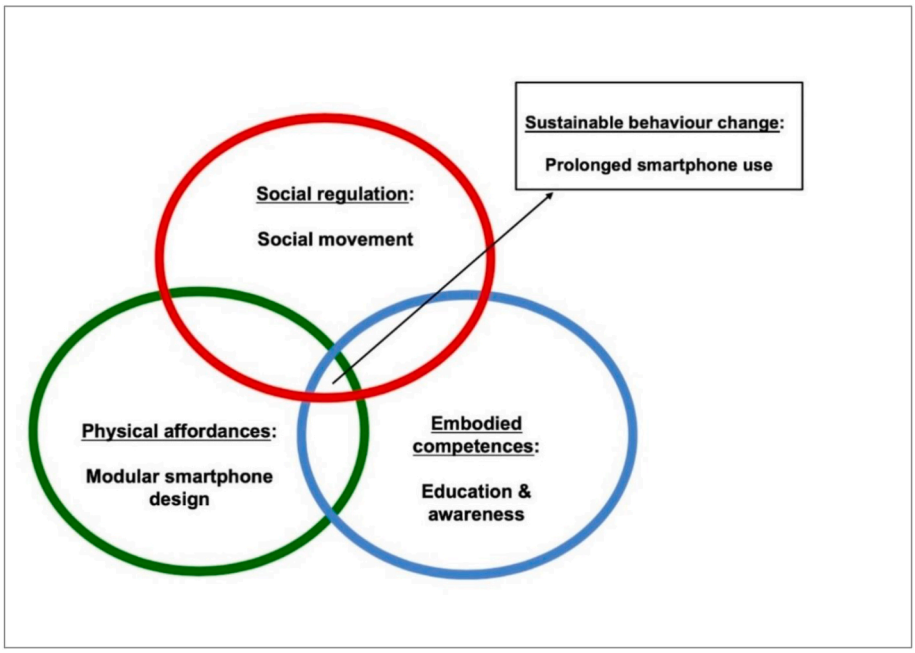

Fig. 4. Installation Theory (Lahlou, 2017) applied to smartphone obsolescence.

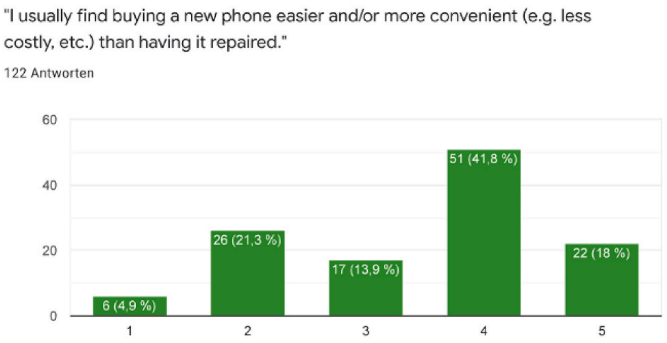

Fig. 5. Results from small-scaled survey about respondents'' concern over smartphone repairability.

lifespan and personalisation. Critically, modular designs can also help overhaul entrenched cultural narratives that devices are disposable. Facilitating emotional durability and meaning creation directly combats the short-term relationships underpinning premature obsolescence (Mugge et al., 2005).

However, improving module accessibility and affordability is imperative. Partnerships with mobile carriers and leasing programs can alleviate upfront pricing barriers to broader adoption. Multiple experts further advised customisable decorative cases to broaden the appeal for identity expression. This materiality also inspires careful use and storytelling, nurturing product attachment. While modular instruments and companies provide solutions for the technological and physical aspects of smartphone obsolescence, modularity is limited in addressing the personal and social dimensions of smartphone replacement, namely psychological obsolescence. Further problem analysis and solutions are required from the perspective of the remaining two layers to tackle this topic and further popularize modular devices more comprehensively.

While modular instruments and companies such as Fairphone provide solutions for the technological and physical aspects of smartphone obsolescence, modularity is limited in addressing the personal and social dimensions of smartphone replacement, namely psychological obsolescence. Further problem analysis and solutions are required from the perspective of the remaining two layers to more comprehensively tackle this topic and further popularize modular devices.I put this back here because it makes a nice transition to the next section, and you must mentin that modular solutions do exist.–>

4.2.2. *Embodied competences – users' interpretive systems*

4.2.2.1. The problem. "Most people sell their old device because they are actively looking for a new one in most cases however, the devices we get are not broken or damaged. So, few devices are returned or handed in with damages. Most devices come from customers that are simply actively upgrading their device, so we have many customers that feel it is time to replace their phones." – Expert 2.

Proske and Jaeger-Erben (2019) state that "looking at the user is important if we want to address the actual use-time (as compared to the technical lifetime) of the device" (p. 58). One reason for this lies in the meaning users give to their smartphone in everyday life and the relationship between it and its user. Similarly, our survey indicates that people perceive their smartphones as an essential part of themselves and who they are Accordingly, only %33.6 disagreed with their smartphone being an important part of themselves (see Fig. 6).

In addition to having certain representations of what a "smartphone" entails, the possession of the most recent smartphone also contributes to the sense of identity as the user's "extended self" (Belk, 1988) and serves as a means for self-actualisation. Other research (e.g., Wieser and

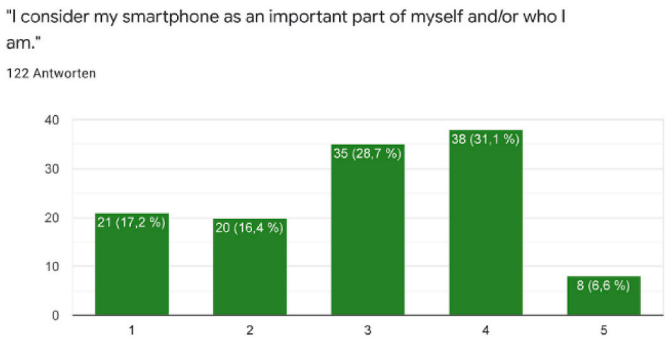

Fig. 6. Results of small-scaled survey illustrating respondents' perception of their smartphone being an essential part of themselves.

Tröger, 2015) has demonstrated that expectations for smartphone lifetime and quality are relatively low. Consequently, it becomes highly convenient for consumers to replace their smartphones, thus, becoming less motivated to repair them. Interestingly, consumers prefer an average lifetime of 5.2 years for mobile phones, although they use the device for 2.7 years. Furthermore, consumers have even lower expectations for reality, assuming an average lifetime of one to two years. Low technical lifetime smartphone expectations mainly arise from poor quality and planned obsolescence (Wieser and Tröger, 2015). Therefore, consumers ultimately become reluctant to spend more on higher-quality, durable smartphones. In other words, exceeding the smartphone lifetime leads to the device becoming mentally depreciated and perceived as obsolete, making it easier for the consumer to replace it prematurely.

Accompanying the psychological factors, users' behavioural characteristics, such as usage intensity, influence smartphone life cycles (Batarfi et al., 2017). Careful or careless usage emerges from users' attitudes towards the device. Also, smartphone users gravitate to specific manufacturers or models while feeling pressured by newly introduced smartphone models.

Considering the significance of the users' competencies in their relationship with the smartphone, it is evident that a "durable" device alone cannot solve premature obsolescence. Therefore, besides focusing on the technical lifetime of the products through robust and repairable design, addressing the user and her expectations directly is crucial. As such, effective strategies must be created to increase perceived durability. Addressing perceived durability and obsolescence demands a detailed consideration of the meanings of smartphones in everyday life and the relationship that evolves between a device and its user.

4.2.2.2. The Solution. This layer of Installation Theory (interpretive systems) is distributed over individual human minds and bodies through experience, education and exposure to discourse (media, advertising, etc.). Therefore, solutions offered in the first layer of our analysis are coupled with those which bring the user into the project's scope. While modular smartphones technically enable the user to replace defective parts, it is essential to complement this with transmitting the necessary knowledge and skills to the user (the "embodied competencies of Installation Theory). To this end, companies that aim to address premature smartphone replacement need to educate users and ensure that they have the required embodied competencies to realise all that modularity may physically offer. Educative YouTube videos, additional "How to …" sections, first-person repair clips, and continuous and convenient customer support may be implemented to facilitate behaviour change further.

Moreover, to achieve sustainable behaviour, it is essential to supplement bottom-up solutions while aiming to increase the transparency of environmental information (Liu et al., 2015). To this end, the involvement of various stakeholders ensures more comprehensive strategies, for they can reach and impact a wider audience through mutual collaborations. Environmental awareness acts, and campaigns can be held by involved stakeholders, including governments, businesses, ENGOs and others, to further facilitate prolonged smartphone usage by impacting perceived obsolescence (Abuzeinab and Arif, 2014).

Additionally, green awareness is a significant contributor to consumers' sustainable consumption. Studies indicate that increasing awareness of environmental issues, such as depleting natural resources, global warming, and pollution, causes people to consider such issues more during purchasing decisions (Banytė et al., 2010; Young et al., 2010). Therefore, increasing consumer awareness and providing smartphone users with the necessary information to foster sustainable decision-making may be implemented through awareness and empowerment campaigns focusing on the environmental impacts of premature smartphone obsolescence. As such, campaigns can use graphic visualisations (see Fig. 7) to properly frame the harmful impact of such unsustainable behaviour. In designing user awareness campaigns and utilising gain/loss framings of ad messages in environmental conservation campaigns, stakeholders may benefit from contextual cues that stimulate feelings of guilt, shame and anger. Such emotions may invoke environmental activism, thus eliminating the gap between attitudes and behaviour while also harnessing consumers' sense of self-efficacy (Harth et al., 2013). Moreover, while the internet and social media platforms have significantly increased accessibility, appropriate media platforms should be chosen according to the emotional context of the ad messages. In this sense, context-induced emotions have been demonstrated to stimulate consumer response to the underlying environmental messages (e.g., Shapiro and MacInnis, 2002; Baek and Reid, 2013).

Furthermore, materials like wood, leather and stone are "commonly described as ageing gracefully" since they become more valuable and visually enhancing as they age (Bridgens et al., 2017). As such, coupling these materials with the fact that phone cases are already extensively used for protective and visual purposes could foster and motivate prolonged smartphone usage by creating an emotional connection between the user, the smartphone and the outer appearance of the device (see Appendix B).

Across interviews and open-ended questions, users expressed hesitancy to self-repair phones due to skills gaps and negative quality perceptions. As Interviewee 3 summarised, "Most people find repair processes daunting." However, evidence shows capacity building can overcome these psychological barriers inhibiting maintenance. Wieser and Tröger (2015) found that hands-on repair workshops increased intentions to fix devices personally. All experts thus advised instructional company resources to enable competencies around modular

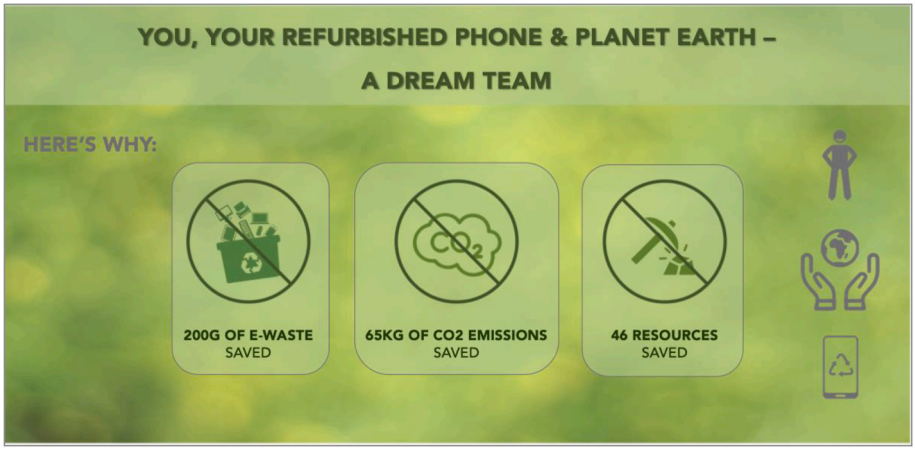

Fig. 7. Illustrative awareness and empowerment campaign.

customisation. Several users wanted step-by-step video guidance on part replacement and operating system upgrades. Our survey also revealed that improving environmental awareness and attitudes towards prolonged ownership as pivotal to reducing obsolescence. Multiple interviewees recounted customer exchanges where replacement rationales showed limited sustainability consideration. An emphasis on quality and social outcomes was judged as better persuading consumers than pure cost savings. Interviewee 2 concluded that "appealing to people's values often works best." Thus, multi-stakeholder education campaigns are imperative to broaden competencies while positively shaping obsolescence perceptions and priorities from an early age. Gamification through modular customisation and DIY repair workshops could further foster engagement.

Although embodied knowledge of how to use the affordances offered by modular smartphones and enhanced consumer awareness will impact the desirability of prolonged smartphone use by highlighting the importance of longevity, more is needed to execute appropriate behaviour. As such, we must analyse the third dimension to ensure that the resulting behaviour is appropriate and socially accepted.

4.2.3. *Social regulations – channelling behaviour through institutions*

4.2.3.1. The problem. Roles and status are "learned expectations about which behaviour people should have in a given situation" (Lahlou, 2017, p. 122), expressed, for example, through fashion (Simmel, 1957). Users carry their smartphones with them almost at all times. On average, they spend 3 h and 15 min a day and check their phones 58 times a day (MacKay, 2019) This has transformed smartphones into accessories and fashion objects that convey users' identities rather than mere technical devices (Fortunati, 2005). Fashion is a vehicle to construct our identity, which, in turn, influences how others see us, resulting in our socially constructed self. Studies have demonstrated the importance of possessing the latest smartphone as a means of social status signalling, especially amongst agents from lower socioeconomic backgrounds (e.g., Abeele and Roe, 2013). Similarly, the smartphone brand serves as a means to signal status. Research indicates that brands play an important role when purchasing smartphones (e.g., Lim et al., 2013; Rakib et al., 2022). Illustrative examples are the recent 'necklaces' brought to the market that allow people to carry their smartphones around their necks overtly. This was further confirmed through our interviews with refurbishing and second-hand phone sellers' employees, as Interviewee 1 mentioned that "you will never fully erase status seeking".

IIn addition, peer influence and social norms further reinforce smartphones' premature disposal. Wieser and Tröger (2015) found that the newness of smartphones in people's direct social reference group, i.e., friends, has a more substantial impact on inter-purchase intervals than functional failures such as incompatibilities and technologically outdated software. Similarly, nearly 25% of the respondents to our survey indicated that using an old phone around their friends made them feel embarrassed. This phenomenon can be explained by the need-to-belong theory (i.e., the fundamental motivation to form social bonds; Baumeister and Leary, 1995) and social identity theory (Tajfel, 1974). The latter defines social identity as "that part of an individual's self-concept which derives from his knowledge of his membership of a social group (or groups) together with the emotional significance attached to that membership" (Tajfel, 1974, p. 69). In this sense, smartphones work as social instruments (Moscovici, 1984), and to stay a part of the social (peer) group, agents need to display the most recent model as "entitlement" for being a member. If a person refuses to do so, it may result in social exclusions (Elster, 2007).

While peer pressure in the previous example is enforced through specific social norms, multiple other norms influence smartphone users' behaviour on a regulatory level. For example, one issue preventing a more sustainable, circular smartphone industry is that users store old smartphones at home rather than return them to the manufacturer or resell them (e.g., Sarath et al., 2015). As long as the social norm is to exchange one's smartphone frequently and storing the old device in a drawer, the agents' behaviour will be channelled accordingly. A similar logic applies to repairing one's smartphone: Litvine and Gadenne (2020) found that people are not used to repairing their devices and seem overwhelmed by being presented with a repairability score. While this score represents a social regulation that should facilitate more sustainable behaviour, steps within the other two layers of Installation Theory must be taken to prove this intervention successful (Litvine and Gadenne, 2020).

Other aspects that constrain and artificially shorten smartphone life cycles include product warranties and fixed-term phone contracts with service providers, which stimulate regular phone replacement cycles, i.e., every one to two years (Tröger et al., 2017). Lastly, many stakeholders, especially mobile service providers and smartphone retailers, further cultivate the rapid replacement mindset by subsidising newer products, thus, essentially ensuring that the customer is persuaded to replace than repair (Proske et al., 2016).

4.2.3.2. The Solution. Tackling the challenges associated with the social layer of Installation Theory in the context of smartphone obsolescence means, first and foremost, addressing the underlying motive that sparks premature smartphone replacement amongst young adults: the need to belong and to be part of a social group one identifies with. Therefore, we suggest creating a social movement to revert the norms of smartphone obsolescence while instilling a sense of community.

Social movements have already been formed in other sustainability contexts. For example, a Slow Fashion Movement offers a platform to take collective action and demand change See illustrations in Appendix C). The "Slow Smartphone Movement" could work similarly, including a website that allows members to connect and engage with each other, for example, through a community forum in which slow smartphone "activists" could exchange tips and success stories. The movement could make use of dynamic social norms, for example, informing people that "Over the past two years, more and more young adults have started to keep their smartphone for more than four years. Help grow the movement!" which could lead to a behaviour change in their members (e.g., Sparkman and Walton, 2017). Furthermore, members of the Slow Smartphone Movement would create online accounts with profile pictures that indicate through specific frames or colours how long a person has kept their smartphone - for the tech-savvy generation. This could be achieved via blockchain (e.g., using cryptography to trace individuals' behaviour, such as their smartphone retention duration) with a golden frame for those who have not replaced their phone in five years (see Fig. 8). This would add a reward as an incentive for sustainable behaviour and serve as a way of signalling (Bird and Smith, 2005) and reinforcing social identity (Tajfel, 1974).

Another approach such a movement can take is offering members pledges to commit to keeping their existing smartphones longer. Pledging has shown to be an effective measure to increase sustainable behaviour, mainly when made in the public sphere (e.g., Costa et al., 2018; Koessler, 2019), as it strengthens the commitment to actions in line with one's values and thus counters cognitive dissonance (i.e., a discrepancy between people's beliefs and actions; Festinger, 1962).

The role of social media - Instagram in particular - is highly relevant in this context for two reasons: Firstly, it offers the opportunity to reach more people, and secondly, influencers can help promote the cause of the movement. Especially for young adults, influencers on social media can significantly impact consumers' behaviour, even without environmental awareness (e.g., Johnstone and Lindh, 2018). To be more concrete, popular influencers of the target group could promote their 'slow' smartphone consumer behaviour by emphasising that they are keeping their phone as long as it lasts or by promoting sustainable alternatives such as modular or second-hand phones. Such campaigns could be funded by the interested stakeholders: government agencies, but also

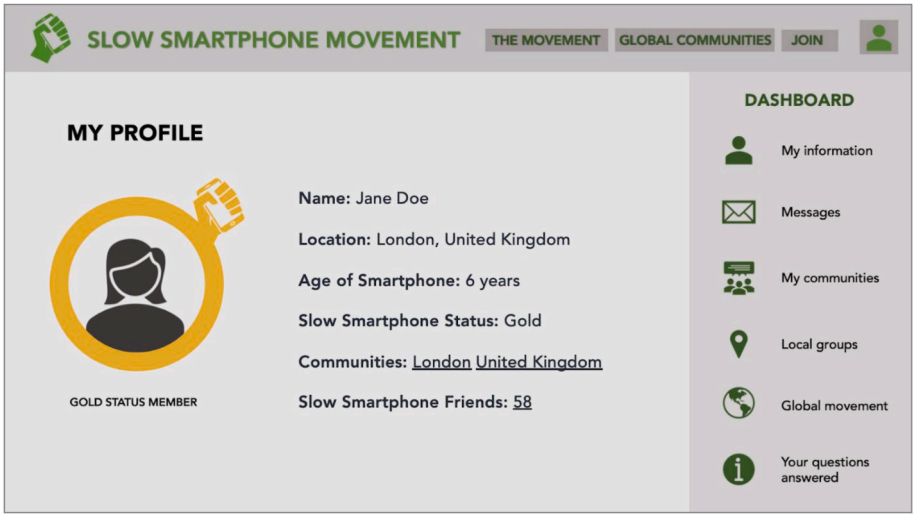

Fig. 8. Illustrative slow smartphone movement Interface.

second-hand retailers and, of course, companies making and selling modular smartphones or their spare parts.

In addition, to get to a critical mass of adopters - following Rogers' diffusion of innovation theory (1962) - and moving away from the individual level, companies could provide their employees with modular phones or strive to keep employees' smartphones in circulation as long as possible. This would lower their costs, and bring them sustainability kudos. These suggested measures would ultimately create a 'new normal' and establish a new social norm: that of not replacing one's smartphone every (other) year.

All experts noted peer influences as highly impactful in smartphone upgrade decisions, especially among youth. Interviewee 5 explained that "teenagers frequently feel embarrassed by older models when with friends." Our user survey confirmed that stylistic elements and brand reputations carried high-status values to signal identity. These social pressures are grounded in technology showering practices, which cultivate expectations of constant newness (Yun and Lee, 2015) .

While recent "right to repair" policy efforts help, our interviewees stressed bottom-up cultural shifts as most potent for combating engrained obsolescence mindsets. Both users and experts responded positively to a grassroots "Slow Smartphone Movement" utilising public pledges to resist premature upgrades. Participant rewards like display badges and runway events were also advised to motivate involvement and gradually redefine social norms. Corporate sponsorship could then scale initiatives through existing brand communities. Transitioning smartphones into fashion statements celebrating longevity presents a promising pathway for mainstream adoption.

5. Limitations and future directions

This paper has investigated determinants of premature smartphone obsolescence among young adults and derived targeted interventions grounded in contemporary psychological theory to promote longer lifecycles. Activity Theory was utilised to define the research scope, ultimately focusing on the first stage in the buyer behaviour model, reflecting a prototypical customer journey along five consecutive decision stages. Problem recognition, essentially the perceived difference between the current and desired state of being, was subsequently analysed through the three interrelated layers of Installation Theory: physical affordances, embodied competencies, and social regulations. Framed by Installation Theory, obsolescence drivers were analysed through literature, interviews and a survey across physical affordances, competencies and social dimensions. Tailored solutions then addressed revealed barriers.

Nonetheless, limitations exist. Proposed initiatives would benefit from empirical testing to quantify intended outcomes. Experimental research should evaluate the efficacy, iterate on the design and isolate synergistic effects between interventions. Furthermore, the focus on young demographics limits generalizability, which could be addressed through studies across age ranges and cultural contexts. Extensions might apply this approach to other electronics categories facing obsolescence, like laptops or tablets. This work aims to spark interdisciplinary perspectives connecting consumer psychology with engineering solutions to progress a circular economy.

Despite the attempt to investigate premature smartphone obsolescence holistically, the paper's limited scope and the inherent nature of scientific inquiry inevitably result in conceptual and methodological limitations. From a conceptual perspective, this research does not explicitly follow the conventional classification of planned and perceived obsolescence, which is frequently found in the academic literature (e.g., Mellal, 2020). Instead, it applies and harnesses the logic proposed by Installation Theory, arguably providing a better toolkit for deriving and structuring practical solutions (Lahlou, 2017), rarely the focus of traditional academic papers. Thus, although advantageous for this paper, this approach complicates seamlessly integrating the present research into the current academic literature. The consumer-centric perspective, deliberately chosen for this paper, also represents one of many possible angles from which to study smartphone obsolescence. However, extensive research, expert interviews, and a consumer survey mitigate the drawbacks of an overly narrow consumer focus, eventually allowing for more holistic and realistic solutions. Moreover, this paper only narrowly touches on governmental interventions because they are considered the last refuge and can supplement the proposed solutions. That is not to say, however, that governments blindly approve of planned obsolescence and remain inactive agents on the sidelines. For example, recent fines for the two major smartphone manufacturers, Apple and Samsung, provide a vivid example of the increasing governmental pressure regarding consumer rights and environmental protection (Kuenzler, 2017). Lastly, this paper only briefly examines the limits of the overarching economic system, which, given the current legislation and incentive structures, actively promotes consumerism and makes large-scale changes virtually impossible (e.g., Speth, 2008). Methodologically, this paper heavily relies on empirical research and secondary data for both problem identification and potential solutions. However, primary data in the form of a small-scale survey and several expert interviews supplement it. Nevertheless, because of the novelty and uniqueness of the above-presented solutions, which stem from a combination of various theoretical concepts and streams of thought, some

still require empirical validation. Therefore, an avenue for future research is to test the above-articulated solutions for feasibility and efficacy.

While this research makes significant contributions, limitations provide opportunities for future work. The paper relied extensively on literature and small-scale primary data, warranting large-scale empirical confirmation of results. Experimental or longitudinal studies should evaluate proposed solutions for quantitative efficacy as well as potential synergy between integrated initiatives targeting different obsolescence dimensions. Research into optimal intervention packaging would further refine implementation.

Additionally, focusing on young demographics may constrain generalisability. Applying similar Installation Theory grounded analyses across other age groups could reveal nuanced drivers and needs. Comparative studies may also examine cross-cultural differences in obsolescence contributors, particularly between individualistic and collectivist societies. Models could then be refined to improve contextual relevance.

Further research might extend this approach to additional electronics categories facing extensive waste issues from short lifecycles, such as laptops, tablets or household appliances. Tailoring the Installation Theory framework to map category-specific consumer journeys would enable tailored interventions targeting pain points across the usage lifecycle. Eventually, a systemic methodology could emerge for assessing and responding to obsolescence challenges across electronics verticals.

From a practice perspective, collaborating with industry partners would support solution pilot testing while improving adoption readiness. Evaluating modular design or educational program effectiveness could verify the Return on Investment for manufacturers while optimising rollout. Policy data could also assess lifecycle developments following "right to repair" legislation. Ultimately, this research aims to inspire interdisciplinary perspectives connecting consumer psychology, engineering and sustainability to accelerate the transition to a circular economy.

6. Conclusion

This study utilised a mixed methods approach to investigate the determinants of smartphone obsolescence and propose solutions to extend ownership lifespans. Findings from the literature analysis, expert interviews, and user survey converged to provide a multi-layered understanding of obsolescence drivers grounded in contemporary psychological theory. Key determinants at the physical layer included deteriorating battery performance, storage capacity, and general wear-and-tear issues degrading the smartphone usage experience over time. Outdated technical specs and disappearing software support introduced obsolescence through eroding competence factors. Socially, peer influence and status pressures propagated cultural discourses of incessant upgrades being necessary regardless of device condition.

Derived interventions targeted revealed barriers across dimensions. At the physical level, increasing access to affordable repairs and parts could counter component degradation. Promoting software updates and backwards compatibility addressed competence constraints. Finally, education programs and social marketing initiatives have potential to reshape sociocultural narratives perpetuating rapid obsolescence.

Smartphone modularity represents a promising starting point to address the problems associated with physical affordances, such as broken parts, worn batteries, and planned obsolescence. Yet, modularity merely addresses one arguably minor aspect of obsolescence, neglecting the psychological determinants of premature smartphone replacements. Therefore, extensive consumer education and awareness campaigns highlighting the alternatives to purchasing new products could tackle issues associated with embodied competencies. As such, we suggested that various stakeholders, including refurbishers, engage in and expand already existing consumer awareness campaigns on the harmful environmental impacts of premature smartphone replacement. Lastly, social regulations manifested partly in the universal need for belonging and social inclusion, represent the last driver of smartphone obsolescence. As inherently social creatures, humans are naturally influenced by their respective peer groups and underlying social norms. Thus, addressing conformity pressures and normative expectations requires redefining social norms. Such a change could be induced by social movements promoted by prominent influencers that serve as early credential adopters, evoking a sense of urgency to change these harmful behaviour patterns prevalent amongst millennials. Virtual communities and reward schemes could foster lasting normative change, eventually helping redefine the detrimental consumerism culture.

Moreover, smartphone modularity enables easier repair and customisation, increasing physical durability and emotional longevity. Focused consumer education builds knowledge and skills while reshaping negative perceptions inhibiting maintenance. A "Slow Smartphone Movement" utilises public commitments and online communities to redefine harmful cultural narratives of constant replacement underlying obsolescence. Together, these synergistic pathways offer systemic, evidence-backed strategies to fundamentally transform ownership mindsets and patterns, especially among youth demographics. While contemporary socio-psychological perspectives have gained traction in sustainability, applications to technology management remain underexplored, representing a valuable research gap this work sought to bridge. The unique integration of Activity Theory and Installation Theory lenses provides a novel framework for linking obsolescence experiences to targeted interventions along technical, psychological and social lines. Grounding recommendations in user and industry feedback further refined solution viability to ease adoption barriers.

This paper makes three key contributions. First, it provides a novel empirical application of Installation Theory and Multilayered Installation Design to structure a comprehensive obsolescence analysis spanning socio-technical dimensions -this could be applied to other products. Second, tailored interventions grounded in behavioural evidence offer specific pathways for practitioners to combat smartphone disposal. Third and most uniquely, integrating industry feedback and consumer perceptions builds solution relevance while easing adoption barriers. Rather than one-off initiatives, the mutual reinforcement of multi-level changes conveys promise in fundamentally reshaping ownership cultures to promote sustainability. The study contributes empirically-based insights and an integrative theoretical framework to analyse obsolescence holistically. The multi-layered approach unveils nuanced drivers across interactional dimensions between user and device. Practical pathways were proposed to extend lifespans, however further research should continue refining solutions, evaluating impacts over time, and monitoring the evolving technological and social landscape. Overall, the complex factors precipitating premature smartphone replacement observed here underscore the need for ongoing systemic solutions to create more sustainable consumption patterns.

CRediT authorship contribution statement

Atrina Oraee: Writing – review & editing, Writing – original draft, Visualization, Supervision, Project administration, Formal analysis, Data curation, Conceptualization. **Lara Pohl:** Writing – original draft, Methodology, Data curation, Conceptualization. **Daniëlle Geurts:** Writing – original draft, Formal analysis, Data curation, Conceptualization. **Max Reichel:** Writing – original draft, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clrc.2024.100174.

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