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Exploring the Potential of Nostalgia to Extend the Life of the Game Boy

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Theresa Reiterer, BSc

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Wien, 5. Mai 2025

Theresa Reiterer

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Kurzfassung

Mit der zentralen Fragestellung *"Was wäre, wenn wir die ungenutzten Ressourcen, die in unseren Schubladen oder Dachböden schlummern, nützten, anstatt neue Produkte zu kaufen?"* präsentiert die vorliegende Arbeit eine Alternative zu vorherrschenden Konsumgewohnheiten. Dieser spekulative Design Ansatz wird an dem Beispiel vom Nintendo Game Boy, einer über 30 Jahre alten Spielekonsole, erforscht, um auf die kurzlebige Beziehung, die wir zu Geräten hegen, hinzuweisen und Potentiale aufzuzeigen, wie die Lebensdauer von Produkten verlängert werden kann. Veraltete Geräte wieder zu verwenden, indem ihnen ein neuer Zweck gegeben wird, stellt dabei eine wertvolle Strategie dar, die dabei hilft Ressourcen, die in die Herstellung eines Gerät gesteckt wurden, wie Materialien, Wissen und menschliche Anstrengungen, umfänglich zu erhalten und zu honorieren, während gleichzeitig die Erzeugung von Müll vermieden wird.

Nostalgie soll als Leitprinzip dienen. Menschen denken gerne an vergangene Ereignisse zurück, behalten oder kaufen Dinge als Andenken an die Vergangenheit und empfinden oft ein Wohlgefühl, wenn sich an spezifische Lebensabschnitte erinnert wird. Dieses positive Gefühl, das Nostalgie schaffen kann, wird in der vorliegenden Arbeit genutzt, um Interesse an Wiederverwendung zu fördern und zusammen mit ehemaligen Nutzer:innen neue Nutzungsmöglichkeiten für den Game Boy zu erschließen. Besonderes Augenmerk wird dabei auch auf die möglichen negativen Auswirkungen von Nostalgie auf das Neudenken der bekannten Konsole gelegt, inwieweit persönliche Erfahrungen und Erinnerungen das Design beeinflussen oder gar behindern. Die Wiederverwendung des Game Boys für einen neuen Zweck unter dem Erhalt des nostalgischen Wertes ist ein Balanceakt: die Nostalgie des Game Boys wird auf unterschiedlichen Ebenen erlebt und die Gefahr ist groß idealisierte Erinnerungen an das Gerät zu zerrütten.

Der kreierte Prototyp, ein Game Boy Advance SP, der zu einer Smart Home Fernbedienung umfunktioniert wurde, versucht die förderlichen und einschränkenden Faktoren im Zusammenhang mit Nostalgie so umzusetzen, dass das Gerät von ehemaligen Nutzer:innen möglichst positiv aufgenommen wird. Das Ergebnis ist ein Add-On, das auf dem Game Boy montiert wird, ohne die originale Hardware oder Software der Konsole zu zerstören oder dauerhaft zu ändern. Die Diplomarbeit legt nahe, dass dieses Konzept der Erweiterung ohne permanenten Änderungen auch sinnvoll für andere veraltete Technologien sein kann um Wiederverwendung und nachhaltige Lebensdauer von Geräten anzustreben.

Abstract

With the central question *"What if we made use of the untapped resources tucked away in drawers or sleeping in our attics, instead of buying new?"* the thesis at hand presents an alternative to prevailing consumption patterns. This speculative design approach is explored using the example of the Nintendo Game Boy, a gaming console that is over 30 years old, to highlight the short-lived relationship we have with devices and the potential to extend the life of products. Reusing obsolete devices by giving them a new purpose is a valuable strategy that helps to extensively preserve and honor the resources put into making a device, such as materials, knowledge, and human effort while avoiding the generation of waste.

Nostalgia should serve as a guiding principle. People like to think back to past events, keep or buy things as souvenirs of the past, and often feel a sense of well-being when they recollect a specific period of their lives. This positive feeling that nostalgia can create is used in the present work to promote interest in reuse and develop new uses for the Game Boy with former users. Special attention is also paid to the possible negative effects of nostalgia on rethinking the familiar console and to what extent personal experiences and memories influence or even hinder the design. Reusing the Game Boy for a new purpose while retaining its nostalgic value is a balancing act: the nostalgia of the Game Boy is experienced on different levels and there is a great challenge in not destroying the idealized memories of the device.

The prototype created, a Game Boy Advance SP repurposed as a smart home remote, attempts to implement the favorable and restrictive factors associated with nostalgia in such a way that the device is perceived as positively as possible by former users. The result is an add-on that is mounted on the Game Boy without destroying or permanently changing the original hardware or software of the console. The thesis suggests that this concept of augmenting without altering can also be useful for other outdated technologies in order to strive for the reuse and sustainable lifespan of devices.

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CHAPTER 1

Introduction

The rapid advancement of technology often leads to premature disposal of appliances that still function properly. Combined with companies driving consumption by releasing new models of the same product every year, products being deliberately developed not to last, and repair and maintenance being made particularly difficult, it is a logical consequence that product lifetime decreases. Short use and fast replacement characterize the consumption patterns of today's *throw-away society* and have fatal consequences for the environment. Raw materials are extracted, processed into products and brought to the customer, only to be turned into waste shortly after. We are using up natural resources at such a rate that the planet cannot renew them. *Earth Overshoot Day* - the date humanity has consumed more natural resources than the Earth can regenerate within the same year - occurs earlier every year [1].

A measure to counteract this throughput economy is product life extension. Prolonging the time products are being used before they become obsolete beyond recovery can reduce waste and, at the same time, preserve the value that the product offered in the first place. There exist several strategies for extending product life that designers should take into account concerning different life stages of a product. For outdated technologies which have reached their end of life and already became obsolete, end of life strategies for reversing obsolescence come into play.

The obsolescence of a product, the condition of a product no longer being used or useful, however, is not exclusively of objective nature. Human factors play a significant role in this concern. Owning or replacing a product conveys a message about who we are or who we want to be; it is often a sign of status, style and identity. People have a strong preference for new products rather than reusing old ones. Consumers show a certain apathy towards product lifetime. Therefore, developing solutions that actively involve and address consumers is essential.

Although prior research has emphasized the significance of extending the lifespan of products and the associated strategies to achieve sustainability, there has been a notable lack of attention given to concrete examples of reversing obsolescence in outdated technologies. Similarly, the importance of involving users in reimagining such devices has been widely disregarded despite extensive research and documentation highlighting their role in overcoming rapid consumption patterns.

The Game Boy, a portable gaming console released more than 20 years ago, serves as a prime example of an outdated technology that has lost its relevance in today's world. I personally still own one but do not use it anymore. Like many individuals of my generation, I hold a deep emotional attachment to this piece of technology, as it evokes cherished childhood memories. It is all the more unfortunate that this well-designed interaction device is not used anymore, even though it still functions properly. Therefore, the Game Boy serves as a compelling case study, representing a device that has once captivated an entire generation and now finds itself unused. By capitalizing on nostalgia, the Game Boy has the potential to become not just a relic of the past but be used well in the future.

1.1 Research Aim and Guiding Questions

This thesis explores the repurposing of the Game Boy with a central focus on nostalgia for extending product life, using it as a prime example of outdated technology that is symbolic of the past. The results of the thesis are expected to show how speculative design workshops can effectively harness the power of nostalgia, leading to the creation of novel repurposing ideas for the Game Boy. Engaging in user participation will identify new design concepts beyond existing enthusiast communities, which support product life extension and make productive use of nostalgia. The research should demonstrate what criteria guide participants in determining which ideas for multiple lives of the retro console are worth pursuing and how this reflects the tension between preserving nostalgia and reuse aspirations, revealing their connection to the device and the significance of personal memories. This user-centered perspective guides the creation of a prototype that resonates with users' sentiments, emphasizing the potential for prolonged product use. In summary, the research aims to illustrate the potential of nostalgia for sustainable behaviors, leading to a tangible outcome that benefits not only the Game Boy but also the broader landscape of obsolete technologies by promoting more sustainable product life cycles. In particular, the thesis tries to find answers to the following three questions, focusing on different aspects of nostalgia, extending product life, user perception and broader applicability:

- How can nostalgia be effectively utilized to find new ways of repurposing and extending the lifespan of outdated technologies in sustainable and innovative ways?
- How does the tension between preserving nostalgia and the desire to repurpose old technologies, such as the Game Boy, impact users' perceptions and creative

envisioning of multiple lives for these devices?

- What are the broader implications and lessons learned from the repurposing of the Game Boy for extending the product lifetime of other outdated technologies and how can these findings be applied to inform sustainable interaction design practices in the context of outdated technologies?

1.2 Structure of the Work

Following the introduction, the thesis is structured into seven chapters, each describing a different step or aspect of the work:

The **Theoretical Foundation** chapter outlines topics that give context to the work at hand by briefly explaining obsolescence, consumers' responsibilities in defining useful lifespans of products and ways to counteract fast consumption.

In **Related Work**, existing literature on nostalgia, product life extension performed by users and Sustainable Interaction Design is reviewed. By discussing these three topics, the chapter illustrates the thesis' approach of leveraging nostalgia for product life extension, guided by considerations of material impact and sustainable design strategies available to designers.

Methodology provides a description of the methodological approach employed in this thesis. First, an overview of the research structure and the primary mode of inquiry, Participatory Speculative Design, is given. The remaining sections go into detail about the different methods applied, including two workshops with participants, online research, the design of a prototype and the collection of users' sentiments on the prototype.

Exploration presents the findings of the first phase of the research, which examines the nostalgic appeal of the Game Boy and opportunities and limitations for new uses of the device. After discussing the findings of the individual methods applied in the exploration, the chapter gives an outlook on how the gathered insights can inform the design of a repurposed Game Boy.

In **Design**, the process of repurposing the Game Boy as a smart home remote is documented. Considerations guiding the development of the prototype are explained alongside insights from the exploration, which shaped the final outcome. The chapter also presents the findings from users' sentiments on the design artifact.

The **Discussion** chapter interprets the findings of exploration and design with reference to knowledge from the existing body of research. It answers the research questions by highlighting the potential of nostalgia for the reuse of outdated technologies, the conflicts that arise in envisioning new uses for the Game Boy and the implications of this process for other outdated technologies. In addition, the chapter describes the contributions, limitations and future work of this thesis.

Finally, in the **Conclusion**, the key findings of the research are summarized.

CHAPTER 2

Theoretical Foundation

When talking about how an old technological device such as the Game Boy can be given a second life, aiming to fight fast consumption and valuing the materials and manufacturing that went into creating it, it is considerably important to touch upon various topics that influence and guide the undertakings of this thesis. The following sections highlight the multiplicity of factors that are not only essential for understanding the work at hand, but also for assessing its relevance in today's fast-paced world characterized by short use of products and rapid replacement. As the general debate on sustainable development and related topics should be made accessible to a wider audience, this chapter aims to provide the information needed to engage in conversations about obsolescence, fast consumption and ways to counteract the trend of premature disposal of functioning appliances.

2.1 Obsolescence and Fast Consumption

Although one might wish for it and it poses an answer to major concerns in economic design, products do not last forever. Even more so technological devices in a fast-changing world of fashion trends and technological advancements. It is inevitable that a product becomes obsolete at a certain point in time. However, the reasons why products are not used anymore or even get disposed of by consumers are less straight forward. It is not only functionality that defines a product's usefulness, but an interplay of different factors.

Defining a product's lifetime solely by functionality is insufficient [16]. Functionality is a seemingly objective measure that, when it is not given, defines a definite state of a product. However, describing product lifetime in terms of functionality would neglect the fact that whether a product is functional or not is highly subjective and that the non functional state can be reversed. In fact, consumers often discard products that still function properly [15]. To adequately account for the complex range of reasons why products get disposed of, it makes sense to incorporate the term obsolescence in the definition of a product's lifetime. The umbrella term obsolescence describes a product

being no longer considered valuable or useful by its user [11]. It is representative of the various causes a product gets "worn out". Adding this notion of an out of order state judged by the user that can be reversed, the product lifetime can be understood as *"the duration of the period that starts at the moment a product is released for use after manufacture or recovery, and ends at the moment a product becomes obsolete beyond recovery at product level"* [16, p. 519].

The subjectivity of obsolescence, and by extension product lifetime, is made more clear by the distinction between absolute and relative obsolescence. *Absolute obsolescence* refers to technical failure—an internal limit set by design, and largely a manufacturer's responsibility [14]. Designing for longevity involves making products more durable, repairable, and upgradable. On the other hand, *relative obsolescence* is driven by user perception. As mentioned before, people often dispose of functional products and by that they significantly influence the life span of appliances. The desire to replace an appliance comes from comparing it with newer models, guided by psychological (loss of attachment or interest), economic (cost of repair vs. replacement) or technological (inferior specifications) reasons. Given these varied motivations, relative obsolescence tends to have a greater influence on product lifespan than absolute obsolescence [14][17]. The exploration of the various factors contributing to obsolescence has discerned more categories than the before mentioned. To help designers better understand these dynamics, Burns identifies four types of obsolescence: technological, economic, aesthetic, and social [11]. Technological and economic reasons align with the notion of the above described reasons for relative obsolescence. Aesthetic obsolescence arises from changes in style, wear, and fashion and thus it has similarities to psychological obsolescence. Social obsolescence, however, adds a broader context: products lose value when societal norms shift, such as due to environmental awareness, health concerns, or legal changes.

Throughout this thesis, the term "outdated technologies" will be used to describe appliances that are no longer used or discarded due to the complex range of reasons described in this section. It is not specifically targeted at the concrete example of products having little value because they are "out of date" due to trends or fashion, but should illustrate the multifaceted relative obsolescence where the owners are responsible for deciding whether a product is still worth keeping.

2.1.1 Consumer Attitudes and Behavior

Today's consumption patterns are characterized by short use and fast replacement, resulting in a fast-paced turn over of goods, from resource extraction to disposal [6]. Especially with electronic devices, short lived relationships emerge from the rapid replacement of older products with newer ones [34]. This is indicative of the significance of relative obsolescence and consumers in dictating the useful life of products and as a consequence the avoidable generation of waste.

A problem lies in consumers lacking the necessary information to make informed decisions about longevity [15]. At the point of sale, consumers are not adequately informed about

the intended lifespans of appliances, and it is difficult for them to judge if a product is designed for long use based on the available information such as brand or price [14]. However, although consumers express that they want products to last longer, consumer behavior does not reflect this desire [17]. Consumers are described to show apathy towards product lifetime, adopting a passive attitude and seeing the responsibilities as lying with manufacturers or political decision-maker rather than reflecting their own consumption behavior [7]. It was found that consumers often explain the short durability of products with the fact that manufacturers deliberately design products to become obsolete ("planned obsolescence" [37]), or that the capitalist system forces such sales strategies [58].

Another reason why consumers do not follow a more sustainable consumption pattern, is that the connection between longer lasting products and potential positive effects on the environment are often not recognized [14]. Similarly, short lifespans of products are rather considered to be an issue of product quality than an environmental concern. This could be due to the fact that consumers not only perceive product longevity as less important, but also that they have only a weak connection to the concrete consequences of the premature replacement of products [17].

Taken together, the reflection on consumer behavior highlights that better information and stronger cues about longevity, environmental impact and slow consumption are needed to foster more sustainable consumption patterns. It is proposed that consumers should be meaningfully engaged and addressed in tackling obsolescence [6], or that they are involved in the production process, which can encourage longer use as consumers tend to appreciate products more when they have contributed to their creation[15].

2.2 Product Life Extension

To counteract the fast throughput of products and maintain the value of manufactured products for as long as possible, strategies exist to prolong the useful life of products. **Product Lifetime Extension** aims to minimize the consumption of natural resources and the production of waste, while preserving the economic value embedded in products [6]. Interventions to lengthen the time a products is used can be performed at different stages of a products lifetime. In the *beginning of life*, measures such as designing for durability or product attachment should be considered, in the *middle of life*, repair or maintenance strategies are of interest, and in the *end-of-life*, actions such as remanufacture or part reuse can be taken [33]. Den Hollander et al. define these different stages in terms of obsolescence [16]:

- **Resist obsolescence**: Designing products that are intended to be used for a significantly longer time. The aim is to prevent obsolescence from occurring in the first place by embedding physical and emotional durability into the product's design.

- **Postpone obsolescence**: Extending a product's usable life by making it easy to maintain, adapt or upgrade. This approach keeps the product relevant and functional over time.
- **Reversing obsolescence**: Bringing products back from obsolescence by restoring functionality and value of items through repair, refurbishment or remanufacturing. The return to a non-obsolete state relies on designing products that are recoverable.

For the thesis at hand, considering the focus on outdated technologies, the end of life strategies that reverse obsolescence are of importance. Four distinct approaches are described by Den Hollander et al., namely recontextualizing, repair, refurbishing/reconditioning and remanufacturing [16]. The authors introduce the term "recontextualizing" to describe the use of a product in a different context than intentionally designed for, stressing that remedial actions are not part of the process. The explicit exclusion of remedial measures is a distinguishing feature from the more widely used term "repurposing", which offers a rather vaguely description of the extent to which the original product can be altered in order to make it usable for a new purpose. Apart from the differences in the degree of interventions and product integrity, the strategies share the same goal, that as long as a product's obsolescence can be reversed, a new use cycle can begin.

The notion, that products can have multiple lives, as opposed to the concept of a single useful life, which ends once a product is (considered) obsolete, is also implemented in the Sustainable Product Life Cycle (SPLC) model [46]. This updated model to traditional product life cycle understandings highlights the importance of reuse and repurposing in the life of a product. Accordingly, once a life cycle of a product has ended, there exist two ways how the product or parts of it can remain in use: First, if the products can be used for its original purpose, the product should be reused, and remanufactured if necessary. Second, if a product cannot function as originally designed for, or if its use is no longer required, it should be repurposed. These reuse or repurpose iterations encourage better exploitation of resources, human effort and manufacturing time. Recycling, in contrast, only makes use of the material, other resources such as manufacturing are not preserved.

However, given the many strategies to deliberately prolong the life of products beyond mere physical durability, it still depends on the use(r) how sustainable these measures are: *" ... efforts to extend the technical lifespan are meaningless if the product is not used that long"* [54, p. 7].

2.2.1 My approach to Repurposing

In this thesis, I will intentionally make use of the vague description of repurposing, as to whether modifications to the artifact are allowed. Since remanufacturing is focused on an industrial process to return to a like-new state [33] and repurposing does not explicitly state to what extended the original product can be changed [16], I argue that there is a definition missing for a product lifetime extension strategy, that aims redeem to a product's value by making it useful for a new purpose, allowing for different kinds of

interventions to fulfill the goal of adding new incentives to use the product longer. In the following chapters, the term "repurposing" will be used to describe such product life lengthening actions. My understand of repurposing correlates to certain aspects from other concepts or is inspired by them:

- *Remanufacture with upgrade* [33]: Embedding technological innovations to remanufactured products to enhance their appeal beyond the original, aligning with evolving consumers' preferences.
- *Augmentation* [41]: Fostering a stronger attachment with the user through material interventions such as reuse, renewal or customization.
- *Resourcefulness* [39]: Giving new life to artifacts or systems by redefining or appropriating their function in novel or unexpected ways.

2.3 The Game Boy

The Game Boy is a handheld gaming console by Nintendo, first released in 1989. The compact design made it possible to take the device anywhere, while also inheriting a feature from home consoles, which made it stand apart from competitors, namely interchangeable cartridges, allowing for different games to be played on the device [35]. The different games, in fact, played a significant role in the success of the console, with titles like Tetris, Super Mario, Metroid, Legends of Zelda and Pokémon being highly associated with the Game Boy [20]. Another advantage of the Game Boy in comparison to handheld consoles of other manufacturers of that time, which were technologically more advanced, was the lower price and the longer battery life [35, 44].

The design of the console significantly contributes to its image as *"tech design icon of its time"* [38]. The form is easily recognizable and the buttons designed in a way that makes it possible to understand their function by looking at them. The Game Boy is further described as *"pop culture phenomenon"* and as having *"cultural impact"* and *"historical legacy"* like almost no other console [27]. This is also evident from active collector's markets and enthusiasts, who show appreciation for a device that was released more than 30 years ago. Even for former users who do not actively contribute to the legacy of the Game Boy staying alive, the console holds value: *"A lot of people still have their Game Boys, tucked in a drawer or an attic box. Their sentimental value is such that people can't quite bring themselves to throw them out"* [38].

After the original Game Boy from 1989, there were several successors, including the Game Boy Pocket (1996), Game Boy Light (1998), Game Boy Color (1998), Game Boy Advance (2001), Game Boy Advance SP (2003) and Game Boy Micro (2005) [44]. In this thesis, the term "Game Boy" will be used as a representative for all the Nintendo handheld consoles of that time (1990s to early 2000s), and only when differentiation is necessary will explicit model names will be mentioned.

CHAPTER 3

Related Work

The following review of related work lays the foundation for my research by outlining existing knowledge and identifying gaps where my work contributes. It is sectioned according to the three concepts that underpin this thesis: (i) nostalgia, (ii) extending product lifetime and (iii) Sustainable Interaction Design. By discussing significant works in their respective field, this review demonstrates my approach of drawing on social science findings on nostalgia to advocate for extending product life cycles, while also considering material factors and the scope of action available to designers to encourage more sustainable effects. Together, these perspectives provide an understanding of how both designers and consumers contribute to prolonging product lifetimes, and how these insights can inform more sustainable design strategies. In addition to the literature that aligns directly with the thesis topic, this review also considers broader publications, as they contribute to a more holistic view and provide valuable insights that can inform the research. Accordingly, various strategies for prolonging the use of objects in practice will be discussed, not just repurposing. Given the limited research explicitly addressing the extension of digital product lifespans, the review also includes studies on non-digital products to offer broader insights into the motives driving people to engage in product longevity practices, despite the thesis focusing on outdated technologies.

3.1 Nostalgia

Nostalgia is commonly defined as a sentimental and bittersweet longing for the past, a wistful desire to re-live or re-experience memories with personal or collective significance [51, 12]. It is a predominantly positive emotion, yet with a bittersweet connotation grounded in the yearning for the happiness of a former time, which can be both pleasurable and sad, given that relicts of the past cannot be revived. Further properties are the reflection of social interactions in nostalgic memories, the idealization of past experiences and the positive effects of nostalgia on self-identity and well-being [60]. More specifically,

highlighting the positive effects, nostalgia serves self-oriented, existential, and social functions [51], as it:

- Fosters meaning in life, particularly through enhanced social connectedness and a stronger sense of self-continuity [50].
- Supports self-positivity, personal growth, and orientation toward one's ideal self [61].
- Enhances well-being, life satisfaction, optimism, and a sense of purpose, while countering loneliness and social exclusion [61].
- Regarding outdated technologies, it helps individuals create meaning from past experiences, as they reflect on aspects such as connection to stage of life, time and effort invested in the device and shared social contexts [3].

Nostalgia can be triggered by both external stimuli, such as music, smells or artifacts, and internal states, like loneliness, boredom or meaninglessness, where nostalgic thoughts help to cope with the discomfort [51]. These triggers and the longing for past experiences can be exploited in consumer products, as highlighted in the following section.

3.1.1 Driver for Consumption

Nostalgia plays a significant role in consumer culture, where individuals seek to reconnect with the past through the purchase of products that evoke earlier times [26]. These goods, whether authentically retro or designed to simulate the past, serve as symbolic anchors to meaningful personal or cultural memories, often associated with a sense of material connection with a "better time" or "home". Products are designed to cater to a nostalgic sensibility, enhancing the product's emotional appeal and attractiveness, which is further reinforced by media and market trends [52].

Moreover, nostalgia in this contexts is not only about reminiscence, but also about training consumers in a nostalgic consumer behavior. The aim of nostalgia catering products is not merely to evoke past experiences, but to simulate and repeat them, fostering a continuous cycle of nostalgia-driven consumption [52]. In this way, nostalgia becomes both a tool and a target of consumer behavior.

3.1.2 Nostalgia in Gaming and Technology

In the context of gaming, the impact of nostalgia is apparent in the retrogaming boom, where nostalgia motivates players to revisit old games on authentic old devices, through emulators, by collecting associated artifacts, or coming together in communities who appreciate old games [52]. Accordingly, the retrogaming phenomenon is not only about gameplay but also about subcultural identity, collective memory, and the preservation of digital heritage by amateur enthusiasts and hobbyists. Nostalgia not only plays a

role in how original games and consoles from the past are valued today, but also in the acceptance and popularity of modern games which incorporate elements from treasured old games. This was observed with the mobile augmented reality game *Pokémon Go*, for example. It was found that anticipated nostalgia plays a role in users' motivations to play the game [60]. Players who associate Pokémon with meaningful childhood memories report heightened positive emotions, joy, and enhanced well-being during gameplay [9]. These nostalgic responses act as emotional bridges between past and present, reinforcing feelings of social connection and vitality [61].

A unique feature, that makes gaming a particularly effective context for nostalgic memories, is that it enables past experiences to be re-lived in an extend that cannot be achieved with other media. Playing video games allows for a more immersive and exact re-living of past experiences, due to the multi-sensory and interactive nature of virtual environments [26, 61]. Unlike music, which only engages the auditory sense, games enable players to return to specific virtual spaces, unchanged from when they last played it, offering a unique form of emotional "homecoming".

Beyond games, *tech-nostalgia* reflects a broader fascination with outdated technologies and retro aesthetics. This includes the fixation on faux-vintage design (new media made to look old) and the revival of obsolete hardware (e.g., film cameras, record players) or creating something new from old media [12]. According to Campopiano, a part of the longing for past technologies is to re-establish tangible, slower, and more familiar forms of interaction in the fast-paced digital world. Terms like *zombie media* describe this trend of bringing "dead" technologies back to life, through repurposing or revitalization of their original state.

3.1.3 Past versus Future

Nostalgia is conflicted at its core — it invites us to return to a cherished past, yet reminds us that such a return is ultimately impossible, or as Boym described it: *"Nostalgia tantalizes with its fundamental ambivalence; it is about the repetition of the unrepeatable, materialization of the immaterial"* [10, p. 10]. In the book *The Future of Nostalgia*, Boym further highlights the conflicting time dimension of nostalgia. Rather than accepting the irreversibility of time, nostalgia attempts to treat time like space, something we can revisit and live in again.

However, nostalgia is not solely retrospective, nor is it objective. *"Fantasies of the past determined by needs of the present have a direct impact on realities of the future"* [10, p. 10], Boym said in their book. Therefore, nostalgic memories are not purely factual, they are filtered through present needs and desires. Those reshaped memories can influence the future we try to create. In this way, nostalgia becomes a creative, future-oriented force.

Nostalgic memories often glorify the past, framing it as intrinsically better or simpler [26]. This idealization can clash with reality. When people revisit old games or technologies, they may experience nostalgic disappointment, realizing the experience does not match

the memory [61]. Games once loved may now feel overly difficult, undermining the joy originally associated with them. This gap between memory and reality can evoke frustration or feelings of nostalgic regret.

3.2 Extending Objects' Life Cycle

The ways in which an object's life cycle can be extended are multifold, as are the motivations behind these practices. Objects can be repaired [56], change owner [29, 24], be appropriated for new uses [2, 57] or altered to suit other purposes than originally designed for [30]. Additionally, parts of a product may be given a second life by salvaging and reusing individual components [25]. As for the motivations for prolonging the life, they include sustainable concerns [56], lower costs [43] [30], nostalgia [30], personal challenge [49], fun and enjoyment of the activity itself [53, 49, 43], creative satisfaction [2] and innovativeness [49].

Together, these studies highlight that the interest in examining prolonging product life endeavors lies not only in how objects are reused, but also in the rationale behind these actions and the conditions that contribute to their implementation. A particular interest for this thesis are findings related to activities prolonging the life of retro video consoles, which will be discussed at the end of this section with reference to modder communities. Before that, the section explores aspects shaping broader reuse practices, beginning with the role of users as designers.

3.2.1 Users as (Sustainable) Designers

After a product has been released to the market, consumers become significant actors in shaping its continued use and potential for reuse. HCI research has increasingly recognized the importance of studying how non-expert users engage with, adapt and remanufacture products beyond their intended function or useful lifespan. Such sustainable actions can be as simple as using objects in the home slightly different than intended to suit evolving needs. Individuals who appropriate and reimagine artifacts in that way have been described as *everyday designers* [57]. Through *design-in-use*, they repurpose existing designs and enable new functions to emerge, which aligns with sustainable principles of renewal, reuse and invention. Other users more deliberately chose to prolong the life of otherwise discarded objects by creatively reusing e-waste as a decorative item or functional device [34].

Regardless of whether users actively intend to extend a product's useful life, more often than not they are not aware of the sustainable significance such actions imply. This is also found by Huh et al., who discovered that people who buy outdated computers to reuse them are hardly guided by pro-environmental thoughts, making them *unconscious agents of sustainability* [30]. This highlights the co-creative role of users in shaping more sustainable outcomes, contrasting the sole consumer identity of users, and sustainability not being dependent on features of the product itself [57]. However, there are measures

that designers can take to encourage creative reuse and sustainable identity for users, described in section 3.3. Examining the motivations for reusing products, as described in the following section, substantiates that people unconsciously support sustainable appropriations without explicitly aiming to do so.

3.2.2 Motivations

Across different studies, reasons for engaging in reuse and repurposing practices are multifaceted, ranging from practical considerations to more personal values and identity expressions - often a mix of different factors motivates users. Sustainability commonly being a secondary thought, if considered at all.

In their study on reacquisition practices, Pierce and Paulos found that reasons for buying second-hand often lie in financial means [43]. Buying pre-owned goods enables some people to possess things they could not afford otherwise, while some also express that acquiring things new and in regular stores is certainly more desirable. There are also people with a very different stance on reacquisistion, referring to it as a "lifestyle" which involves political or ethical concerns, owning and buying less, and being reflective of what one wants. Despite the environmentally friendly outcome, many participants did not cite sustainability or "being green" as a primary reason. Besides the people who buy second-hand due to financial necessity or critical concerns, there are others who highlight the process of searching for items as enjoyable and appreciate the unique aesthetic qualities that can be found.

Huh et al. similarly observed that buyers of second-hand PDAs were rarely motivated by sustainability [30]. Instead, they were driven by nostalgia, practical considerations like affordability, or specific functional features that older devices provided. For some, it was an opportunity to own a device they had long desired but could only now afford.

By examining the potential of repurpose practices performed by consumers, Scott et al. illustrate that motivations are often self-interested [49]. They include creative satisfaction, fun, curiosity, and the challenge of learning and applying new techniques. The aim of saving objects was also found to be a driver for reuse practices, however not for environmental reasons but to retain unique features of products. Environmental aspects were generally considered to be of secondary importance or framed as an incidental side benefit. Further, examined consumption patterns show that people keep things because they might be able to use them for something else in the future. This finding aligns with another study where 48% of the participants reasoned storing unused electronics in their homes instead of discarding them with the expectation of needing them in the future [34]. The same study highlights that 11% keep obsolete electronics for their sentimental value.

Jackson and Kang provide a distinct angle by examining the use of broken or discarded electronics in artistic contexts [32]. Here, motivations included not only practical reasons like low cost and availability of materials but also an emotional or imaginative engagement with the objects. Participants valued the "story" embedded in used materials and were drawn to the mystery, aesthetic beauty, and pleasure of uncovering and exploring their

inner workings. Whilst some of the artists interviewed in this study were aware of the positive implications their installations might have, such as calling attention to issues of waste, consumption and sustainability, environmental concerns were again mentioned as secondary motivation. The process itself, often filled with moments of frustration and surprise, was viewed as meaningful and the main driver.

For everyday repairers, motivations are largely practical and personal. Repair is often prompted by necessity (e.g., a broken object that is still needed) and sustained by emotional or financial investment in the item [56]. Sentimental value, family associations, and prior time or money spent contribute to the decision to repair. Further, repairing is often linked to the personal interest in repairing and preserving objects. For everyday repairers, environmental considerations are not a primary motivation for their projects; sustainability is only mentioned in association with responsible disposal of electronics.

Other works (e.g., [2], [57]) highlight how reuse can also serve as a form of self-expression, allowing individuals to reflect their identity and values through the alteration and reappropriation of objects. Remanufacturing obsolete electronics, as examined by Kim and Paulos, was found to be practiced by experts for hobby or creative expression, as it involves a more technical form of reuse [34].

In sum, reuse practices are motivated by a broad variety of self-interest, creativity, identity and values, where sustainability, while present, is often implicit or indirect. Understanding these nuanced rationals is critical for designing interaction technologies that genuinely support reuse practices.

3.2.3 Contributing Factors

The following section outlines factors identified in the literature that either enable or hinder reuse practices by non-experts and everyday designers. These factors influence both the decision to engage in reuse and the form the final outcome takes. They differ in how frequently they appear across studies and in the extent of their impact. While some play a role in whether reuse is undertaken at all, others shape the direction and result of the project.

Expertise The extent to which non-expert users can engage in reuse practices is closely tied to their individual skills and the accessibility of materials and tools. Kim and Paulos identify three types of e-waste reuse, namely reuse as-is, re-make, and remanufacture, that differ by the degree of modification and level of technical expertise required [34]. Everyday repairers typically rely on their hands and common household tools, working within the limits of their competencies and available materials [56]. When these limits are exceeded, such as with intricate electronics, the likelihood of successful repair or reuse diminishes. A similar effect has been found with users often lacking the knowledge to meaningfully reuse complex electronics like computers [30]. For people who strive for self-expression with their projects, their works offer the opportunity to demonstrate

knowledge and creativity [2]. Overall, the feasibility and form of reuse are directly shaped by what users know and what they can access.

Availability of Resources Access to ideas and shared knowledge plays a key role in shaping reuse practices. A lack of accessible platforms or guidance often limits people's ability to creatively reuse electronics, leaving much of this potential to hacker or DIY communities and contributing to the accumulation of e-waste [34]. However, people frequently draw inspiration from others through online platforms, social media, or TV shows, which helps demystify reuse practices and highlight their diversity [49]. For Green DIYers, sharing knowledge and collaboratively building competences are central, driven by a desire to inspire sustainable practices. In these communities, the symbolic meaning and the aspiration to live sustainably often outweigh the importance of perfect craftsmanship or tools [56].

Product Agency The design and material qualities of products can significantly influence their potential for reuse. Aesthetic appeal, such as color, symmetry, or unique shapes, often encourages creative reappropriation, with users repurposing devices based on their external form rather than internal function [34]. This focus on exterior features makes reuse more accessible but can also lead to functional components being widely neglected. For people who are interested in the inner workings of devices, properties such as long battery life, upgradable components, or competitive technical specifications determine if a product is considered for reuse [30].

Some products seem to invite reuse through their quality, perceived soul or authenticity, significantly guiding users' decisions [49]. Design attributes like portability or durability can also serve as cues for new uses, as found with everyday designers appropriating objects in the home [57]. Whilst internal functions and aesthetics can contribute positively to the process of repurposing obsolete electronics, the function of a product might also limit creative imagination by locking objects into specific roles, as described by Jackson et al.: *"A typewriter is always a typewriter while a typewriter"* [32, p. 457].

Effort In the exploration of reacquisition practice, it was found that people often express that it demands more time, effort and work than buying new products [43]. However, for some people the labor involved is said to be meaningful, as it adds value by fostering skills and a sense of discovery. Similarly, Jackson and Kang emphasize how the act of collecting discarded or broken items can spark surprise and inspiration, becoming a formative moment within a broader creative practice in their work [32]. Rather than a barrier, the effort can be embraced as a central and rewarding element of sustainable engagement.

Electronic Devices As mentioned before, with regard to the expertise required for the reuse of electronic parts, digital products are a major obstacle to reuse intentions. The barrier to buying electronic devices lies in concern around durability, reliability, and the

lack of warranties or availability, which make reacquisition risky and costly [43]. Further, many users also feel disconnected from the internal workings of these devices, reducing engagement and confidence. For other product life prolonging activities, the reuse of digital devices often requires a higher level of expertise, as casual users may lack the skills to repair or repurpose them [56, 30]. Unlike non-digital objects, electronics are harder to manipulate with everyday tools, limiting reuse to those with specific technical competence.

Framing Opportunities and drawbacks have been found with the social aspects and the framing of the standing of reusing obsolete products. Often people aim to minimize the "second-handedness", which highlights the social acceptability as a hindering factor for reacquiring practices [43]. As Hood argues, prolonging product life requires a cultural shift from valuing objects for their exclusivity and novelty to appreciating the historical, reused and renewed, thereby making recycled goods and owning fewer things more socially desirable [28]. Another concern with the understanding of prolonging life practices is that they are seen as involving restriction and sacrifice. However, as Scott et al. argue, practices like repurposing should instead be understood as creative engagements, and if framed as such, they have the potential to appeal to a much broader audience, including those not primarily motivated by environmental concerns [49].

3.2.4 Extending the Life of Video Games and Consoles

When discussing how the lifespan of outdated technologies can be extended by repurposing them, with a focus on gaming consoles, a certain group of enthusiasts cannot be left undiscussed: Modder communities. *Modding* describes the process of making technological modifications to hardware or software, with the aim of extending functionality, unlocking new capabilities, or customizing features. The resulting modifications, called *mods*, can take on very different forms, including add-ons to game content or remanufacturing of consoles, as reflected in the two papers whose common themes to extending product life cycles are synthesized below. Both works highlight that the modifications performed by fans and enthusiasts can significantly contribute to extending the life of games and hardware, by challenging technological limits and adding new value.

Contributions Postigo [45] describes fan-produced modding as generating a wide array of content ranging from designing levels and game characters, to content beyond game modifications, such as tutorials or fan-based news. These collective efforts can extend the life of a game, by providing free additional content for other players, which helps sustain a game's relevance and player interest over time.

Graça [22] focuses on modding practices in the context of retro video consoles. It is observed that most retro console mods stay within the visual and physical boundaries of the original hardware. Modders often aim to preserve the aesthetic identity of the consoles, reflecting emotional connections to these devices as nostalgic symbols of the past. Even when the hardware is repurposed for entirely new functions (e.g., turning a

Nintendo NES console into a lunchbox), the vintage look is carefully maintained. While exploring new uses for the hardware, many modders continue to value the original play experience and modify devices in ways that keep them operational for gaming. By coming together in online communities, showing appreciation for old consoles, reinterpreting them for new purposes and actively engaging in their continued use, modders attribute new meaning to technologies beyond their expected obsolescence.

Motivation In [45], creating add-ons is described primarily as an artistic and creative outlet. Modders are motivated by the desire to contribute something of beauty and originality to the gaming experience. Many find satisfaction in enhancing gameplay by introducing unique elements or personally meaningful content. Beyond personal meaning, contributing to the community and sharing creations with others is also considered an important aspect.

With the modding of gaming consoles [22], motivation is often rooted in finding new uses for outdated hardware and creating customized devices that fulfill specific personal needs. While emotional attachment to older consoles can play a role, the primary drive is often the appreciation of modifying and experimenting with technology itself, or "the thrill of technological challenge". The activity is typically non-commercial, pursued as a hobby for entertainment and personal satisfaction. Modders also value recognition from other enthusiasts and enjoy showcasing their achievements.

Skills The work of Postigo [45] emphasizes that modding requires a mix of technical and social skills. Modders often work with scripting languages, graphic design programs, and software development kits, and may also draw on broader knowledge such as history, technology and architecture. These skills allow for the creation of richer content, which can enhance the longevity and commercial success of a game through sustained community engagement.

Graça [22], in contrast, observes that while one might expect individual technical skills to be central to the modding of retro consoles, the actual process is often driven by incremental experimentation. Tinkering and learning by doing are common in the modification of consoles.

Sharing Postigo [45] explains that fan programmers operate within knowledge communities informed by participatory culture. These communities serve not just as spaces for distributing user-created content but also for testing designs and exchanging feedback. Some companies have acknowledged the role of fan contributions in extending the life and appeal of their games and have supported this dynamic by providing communities with source codes or content distribution platforms.

Enthusiasts of vintage video game consoles also form online communities, as described in [22]. These communities function as support networks and a place for appreciating old video game consoles and their modifications. While modding itself remains largely an individual and self-taught activity, recognition from peers and the desire to showcase

one's work are important social aspects. The community's cohesion often revolves more around the technical and creative challenges of modding than shared nostalgia alone, contributing to a broader subculture centered around modding in general.

3.3 Guiding Principles for Sustainable Design

Sustainable Interaction Design (SID), as proposed by Eli Blevis, argues that sustainability should be a central value in the design of interactive systems [8]. Design is framed as an act of shaping future ways of being, and SID asks how digital technologies influence resource use and behaviors that impact the environment. Two core principles guide this approach: first, *linking invention and disposal* — designing new technologies must include an awareness of what becomes obsolete or discarded. And second, *promoting renewal and reuse* — exploring how existing systems can be renewed or reused before making new ones. SID also encourages designing for quality and longevity, rethinking ownership to allow for sharing, and drawing on natural systems to inspire more sustainable relationships with technology.

Rather than just creating sustainable products, designers are called to influence sustainable behaviors and values as an integral part of the design of artifacts. This involves understanding the material effects of digital design, how software drives hardware consumption, and how interaction design can move people from patterns of waste toward repair, reuse and long-term use. Blevis proposes a rubric for assessing the material effects of design choices to help with considerations of sustainability. From most harmful environmental impact to most sustainable, they are: *disposal*, *salvage*, *recycling*, *remanufacturing for reuse*, *reuse as is*, *achieving longevity of use*, *sharing for maximal use*, *achieving heirloom status*, *finding wholesome alternatives to use* and *active repair of misuse*. Of particular importance for the thesis at hand are the notions of *remanufacturing for reuse* and *achieving longevity of use*. When a Game Boy is repurposed to serve a new function, it involves a clear intervention, the reuse is enabled by the remanufacturing of the device. At the same time, considering the Game Boy as having nostalgic value, this kind of repurposing also connects to the longevity of use. By giving the Game Boy a new purpose, its owner finds new value in it, both functional and emotional, which extends its life and prevents it from being discarded.

The sections that follow elaborate in more detail on certain ideas introduced by Blevis as guiding principles for Sustainable Interaction Design. The aim is to synthesize topics and considerations that enable designers to take an active role in shaping sustainable products and behaviors through fostering prolonged product use.

3.3.1 Design for Attachment

Designing for emotional attachment is an important strategy for promoting product longevity, as it encourages users to form lasting bonds with their possessions, reducing the chance of premature disposal. Odom et al. [41] identify four different relationship

styles, that foster attachment. *Engagement* emphasizes the motor-tactile involvement of users, which deepens user interaction through physical effort. *Histories* refers to positive visible traces, such as patina, that enrich an objects identity and sense of ensoulment. With digital devices, histories may emerge from personal data stored on devices. *Augmentation* involves the capacity for users to modify, reuse or customize their products, thus strengthening the attachment by investing creatively in them. Lastly, *perceived durability*, describing the appreciation of the quality and ability of a product to last long, can enhance attachment. For digital products, this can be achieved by adopting universally compatible components or operating systems.

Complementing this, Remy and Huang [47] highlight *value in design* as a means to tackle obsolescence. It involves strategies such as *pleasure engineering*, which aims to sustain long-term satisfaction, and *heirloom status*, where products are deemed valuable enough to keep and inherit. Together, these approaches underscore the role of design in supporting meaningful and enduring relationships between users and their possessions.

3.3.2 Enable Appropriation

Designing for appropriation emphasizes creating artifacts that are open to reinterpretation and user-driven transformation, a quality strongly associated with sustainability, as stated by Wakkary and Tanenbaum: *"The degree to which a designed artifact can be appropriated is directly linked to its degree of sustainability"* [57, p. 371]. This requires designers to recognize and support *design-in-use*, the ongoing interpretation of a product's function and meaning in everyday practice. The authors suggest that instead of designing definite features for defined needs, artifacts should comprise simple qualities that invite reinterpretation and unintended uses. A product's potential for sustainability is, therefore, not solely embedded in its design features but emerges dynamically over time, depending on user contexts and how the artifact serves them [30].

To support appropriation, Akah and Bardzell [2] propose *appropriation-identity design guidelines*, that encourage interaction designers to create products that empower users to become makers who can leverage their existing knowledge to adapt devices to fit their needs and identity. These guidelines promote flexibility in how a product is used, allowing users to reinterpret function, modify interactions and personalize aesthetics.

Material factors can also support appropriation, as found by Maestri and Wakkary [39]. *Flexible*, *substitutable* and *salvageable materials* can foster acts of creative reuse, as seen with everyday repairers. Altogether, appropriation as a design strategy highlights the importance of empowering users to be co-designers capable of shaping and sustaining the life of artifacts beyond their original intent.

3.4 Summary

What was found in this chapter, is that nostalgia, while offering many positive effects, can also be accompanied by conflicts and tensions, that both designers and users can

play a significant role in shaping the lifespan of a product and that sustainability is of minor importance in most reuse or repurpose efforts. The findings reveal topics that have been poorly explored by previous research, and above all, the potential of nostalgia for interventions that aim to prolong the lifetime of outdated technologies.

From the related work, the largely positive emotions linked to nostalgia and its favorable effects on well-being can be gathered. It was shown that artifacts can be triggers for nostalgic memories, serving as symbolic anchors to the past. This is well understood as a means to drive consumption, as products referencing relics from earlier times can be more appealing or attractive. Similarly, in the context of gaming, nostalgia can enhance the motivation to play a game, as observed with Pokémon Go. Catering nostalgia can also entail disappointment, however, given the idealization of the past in nostalgic memories and the fact that the past cannot be revoked. The studied extensions of product life by users and everyday designers highlight the multitude of motivational factors, that encourage people to find new ways of using their products, environmental benefits being, at best, a favorable side effect but generally not considered in the process. Rather, there is a potential to frame reuse practices as being fun and creative, so that the implicitly sustainable activities around product life extension become appealing to a broader audience. Another motivational and enabling factor is communities for sharing inspiration, finding help with projects or gaining recognition from peers, both observed with DIYers and modders. Regarding the role of designers or researchers, there were several strategies found in HCI literature that aim to influence sustainable behaviors and values, and a longer use of products. Building on the general concept of promoting renewal and reuse from SID, the focus on attachment and appropriation in design is considered to be a particularly effective means of lengthening the life of the Game Boy: perceived durability, physical engagement, histories and personalized aesthetics are promising factors to increase the emotional value of the device.

Although the positive effects of nostalgia have been clearly established by literature and how it has been adopted in consumer culture, there has been a notable lack of attention given to intentionally using nostalgia in product life extension. From previous research, it can be deduced that nostalgia can facilitate interventions such as repurposing, as people tend to care for things they feel nostalgic about. Additionally, former users of outdated technologies might have expertise and knowledge about these devices (e.g., details about the interactions), which can help in the process of repurposing. Hand in hand with nostalgia being neglected as an incentive to repurpose objects in research, the negative effects nostalgia or attachment might entail, reflecting the tension of the (idealized) past and changing certain properties to fit present or future needs, are not addressed in literature. Finally, while the motivations and other influencing factors have been examined from different perspectives, the actual process of repurposing a technological device is not well documented in related works. The thesis at hand aims to close this research gap by exploring the repurposing of the Game Boy as a prime example of an outdated technology that is symbolic of the past, with a central focus on nostalgia as a driving force for extending product life.

CHAPTER 4

Methodology

This chapter describes the methodological approach applied in this research. The different methods and considerations guiding the study are outlined to provide insights how the results presented in the next chapter were achieved.

4.1 Research Structure

This thesis explores the repurposing of the Game Boy as a prime example of outdated technology, with a central focus on nostalgia as a driving force for extending product life. To pursue this objective, the research is structured in three interconnected phases: exploration, design and user sentiments. In the first phase, the exploration, four methods were used to investigate the nostalgic appeal of the Game Boy and opportunities for new uses — two distinct workshops with different focuses, a reflection in the format of a questionnaire, and online research. In the design phase, a prototype was created, exemplifying the process and result of repurposing the Nintendo console. Finally, the user sentiments complete the study by capturing how former users perceive the adapted device. Each phase generated qualitative insights that informed and shaped the next.

An overview of the research structure is shown in figure 4.1. The illustration presents the different methods used, each aligned with the research questions they support. Different colors indicate the distinct phases of the project as described above, including the initial step of reviewing existing literature. The bottom of the figure illustrates how earlier methods informed the design of subsequent ones, highlighting the reflective nature of the overall process.

4.2 Participatory Speculative Design

As found in literature and discussed in detail in section 2.1.1, consumers play an essential part in the determining of a products lifetime. It was further shown, however, that many

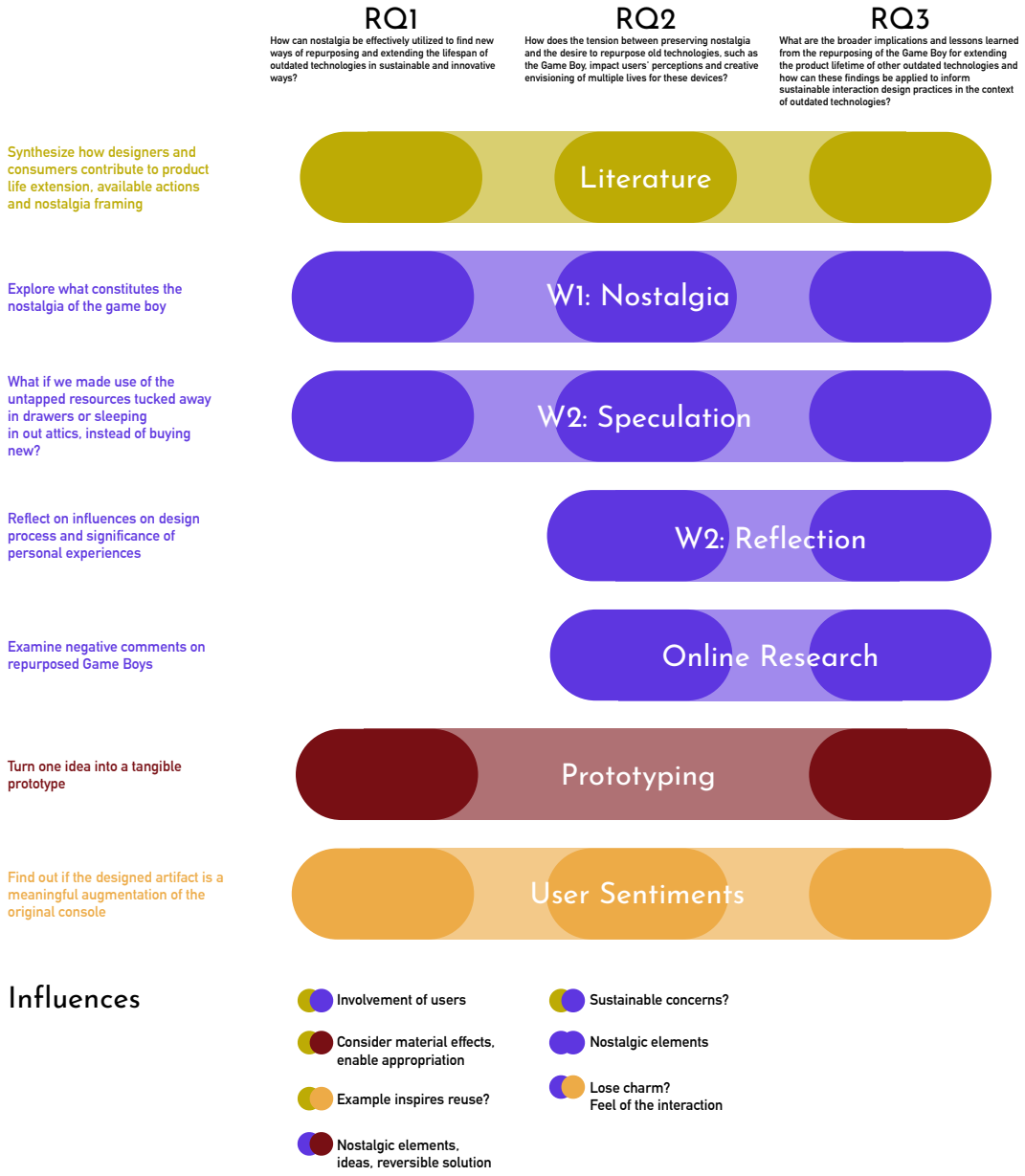

Figure 4.1: Overview of the methodology: Applied methods in relation to the three research questions.

people adopt an indifferent or passive attitude when it comes to dealing with issues related to product longevity. Consumers often do not associate the lifespan of a product with environmental concerns, which contributes to limited awareness and action in this area. In response to these challenges, it becomes necessary to employ methods that involve

consumers in a meaningful way. By employing participatory design methods, there is an opportunity to engage users who are seemingly not interested in, are not concerned with or feel disconnected from a certain topic, as illustrated by previous research [40] [55]. In addition to gaining insights from the concrete outcomes of involving participants in the design process through workshops, the aim is to focus on participants' individual experience and recognize that meaningful impact may lie beyond direct interventions [4] [13].

Whilst participatory design served as the primary mode of inquiry in this research, speculative approaches were incorporated to engage with the imaginative and critical dimensions of repurposing the Game Boy for longer use. Speculative design creates a space for imagining alternative futures, critically reflecting on current practices and illustrating challenging assumptions about the status quo and emerging issues, often related to sociotechnical topics [18] [13] [21]. Typically situated in the future, speculative design aims to facilitate thinking about alternate, favorable futures without the urgency of designing for today's problems [19] [5]. As a means to introduce the speculation to participants, design fiction was used for its capability of building a story world and setting the scene for imagination [31]. The details of how design fiction was implemented in the speculative workshop and the aspects that shaped it can be found in 4.4.3. By engaging non-experts in the speculative task of envisioning multiple lives of the Game Boy, the concrete methodological approach employed is participatory speculative design - characterized by a deep involvement of participants that goes beyond merely viewing and interpreting a designed artifact, as they co-create the final outcome of speculation [18].

To position this project within the domain of design fiction as a research methodology, I adopted the framework proposed by Knutz et al., which defines five key criteria intended to make speculative design projects more comparable and analytically accessible [36].

1. **Basic rule of fiction (What-if scenario?)**
   What if we made use of the untapped resources tucked away in drawers or sleeping in our attics, instead of buying new?

2. **The manifestation of critique (How is it critical?)**
   This project critiques the culture of consumerism and premature disposal by proposing an alternative: repurposing outdated devices. It challenges the current trend of short use and fast replacement, encouraging to rethink how we treat old technologies and their potential for reuse.

3. **Design aims (What are the possible consequences?)**
   The aim is to extend the life of the Game Boy to promote a culture of reusing and repurposing and, as a consequence, reduce unnecessary waste. The project seeks to demonstrate how outdated devices can be reimagined, thus motivating a more sustainable approach to technology consumption that better exploits resources and human effort.

4. **Materialization & form (How is it visualized?)**
   The concept is materialized in the form of a tangible prototype, a repurposed Game Boy, showcasing how an old device can be given new use while retaining its nostalgic charm.

5. **Aesthetic of design fiction**
   This design embraces sustainability, not just in its functionality but also in its aesthetic. The nostalgic form of the repurposed Game Boy serves as a visual reminder of the past while making a statement about reducing waste and rethinking how we interact with technology.

Nostalgia was explicitly not mentioned in the framing of the speculation. It is hypothesized that nostalgia can be both motivational and hindering in repurposing devices linked to fond memories. Therefore, it is of particular interest not to nudge participants of the speculative workshop in any direction regarding the influence of nostalgia. Accordingly, the design fiction presenting the future scenario deliberately leaves out nostalgic cues to allow for unbiased exploration. For this reason, nostalgia and speculative ideas are examined in two separate workshops.

4.3 Workshop 1: Nostalgia

4.3.1 Objectives

The first of the two workshops focuses on exploring nostalgia. Since the aim of this thesis is to design a product that leverages nostalgia to motivate longer use, it is important to learn what makes people nostalgic and how they see certain elements of their past, more specifically their childhood. The goal is for the participants to recall feelings and experiences of growing up in the 1990s and 2000s, to help them to reflect how the Game Boy manages to bring joy in today's world. However, the intended reminiscence of the participants should not only focus on the Game Boy itself but also aim to gain broader insights into the personal childhood memories that shape participants' sense of nostalgia. In that regard, it was also of interest to explore how individual childhood memories overlap, identifying common themes and collective pop-cultural elements that contribute to shared nostalgic experiences.

4.3.2 Participants

The workshop was conducted with six participants, all of whom were born in the 1990s. This demographic was intentionally chosen, as growing up during this period meant they were likely to have firsthand experience with the Game Boy, making them well-suited to reflect on nostalgic associations with the device. Other than their age being within this specific generational group, no additional demographic criteria were applied, as this research aims to address the average non-expert user - someone who might still have

a Game Boy stored in a drawer or attic somewhere but lacks experience in technical modifications or repurposing.

Among the participants was my brother, whose childhood closely mirrored my own, providing a perspective on shared nostalgic experiences. While most participants had varying degrees of familiarity with gaming and handheld consoles, one individual had no particular interest in video games. This diversity in experience allowed for a broader exploration of nostalgia, encompassing not only the Game Boy itself but also the surrounding cultural and social elements of growing up in the 1990s.

The participants were recruited from my personal circle of friends, with some already knowing each other and others meeting for the first time. This selection aimed to create a relaxed and welcoming environment, where conversations felt natural and nostalgic memories could be shared freely rather than resembling a formal or scientific study.

4.3.3 Implementation

The planning of the workshop and the prepared materials were highly shaped by personal experience, with a strong emphasis on creating a nostalgic atmosphere. The aim was to present participants with elements they might remember from their childhood, evoking recollections of that time. Accordingly, I chose materials and contents for the workshop, that I personally - as someone born in the 1990s - consider nostalgic. The prepared materials and activities will be discussed in the subsequent sections in more detail.

The workshop took place in my home to foster an informal and relaxed setting. Since all participants were German native speakers, the workshop was conducted in German to facilitate natural conversations and deeper engagement. To further enhance the intended nostalgic atmosphere, food and beverages were provided that I associate with my childhood, things that I remember were typically served at a children's birthday party.

To ensure authentic reactions, participants were not informed of the workshop's exact purpose in advance. This approach aimed to capture spontaneous memories and genuine responses when discussing the Game Boy, particularly after not having thought about and interacted with it for a long time. However, as the participants were recruited from my personal circle of friends, some had a general awareness of my thesis topic.

Friendship Book
Following the idea of generating an overall nostalgic mood rather than a formal scientific setting, a survey was designed to resemble a friendship book. It aimed to explore participants' recollections of the pop-culture of their childhood and youth, and their memories of retro video game consoles. The format as a friendship book was intended to make the data collection process feel more engaging and personal, evoking memories of filling out similar booklets as children. The survey was structured in two parts: the first two pages were completed at the beginning of the workshop, while the final page was filled out at the end.

Each participant filled out their survey individually, with responses remaining mostly private. However, once everyone was finished the facilitator asked participants to share specific answers to encourage discussion and engagement. A mix of prompts was included in the survey, with some being designed to provide valuable insights for the research, while others were meant to be fun and entertaining, further immersing participants in the nostalgic experience. This also helped break the ice, as some fun prompts, such as *"If I were a Pokémon, this is what I would look like"*, led to participants sharing their drawings and laughing together. The complete survey can be found in Appendix A.

Associations

To explore participants' associations when confronted with elements from their past, an interactive presentation was prepared using *Mentimeter* [1]. Each slide depicted either an image or played a sound representing popular cultural elements from the participants' childhood and adolescence years in the 1990s and 2000s. They included TV series, movies, toys, gadgets, food, stores, games and activities. With the interactive poll tool participants could freely enter as many associations as they liked via their smartphone, with responses remaining anonymous. After a set of answers was received, they were displayed in the form of a word cloud, allowing everyone to see common themes and shared recollections. This approach aimed to capture the overall sentiment of elements from the past - whether they were predominantly positive and whether certain elements evoked similar memories across participants.

Playing

An essential part of the workshop consisted of the participants interacting with old video game consoles. This activity aimed to capture the moment of rediscovering familiar technology from their past, evoking memories and emotional responses to devices they might not have used in years. To achieve this reconnection, a broad variety of old gaming consoles where provided, ensuring that each participant would likely encounter at least one device they owned or played with as a child. These included not only Nintendo handheld devices but a selection of consoles, games and accessories that were popular in 1990s and 2000s. More specifically, the consoles provided and prepared for this hands-on activity were: Nintendo 64, PlayStation 2, PlayStation Portable, Nintendo Game Boy Classic, Game Boy Color, Game Boy Advance (borrowed from one of the participants), Game Boy Advance SP and Nintendo DS. An excerpt of the materials can be seen in 4.2.

The participants were free to choose which console they wanted to play with in the 30 minutes allocated for this activity, no task or further instructions were given by the facilitator. While a few notes and observations were made, no specific data was systematically collected during this phase. Instead, the experience served as a foundation for the subsequent task, in which participants were asked to reflect on and answer questions about the Game Boy.

[1] https://www.mentimeter.com/, Accessed: 04.05.2025

Figure 4.2: Workshop 1 impressions: Selection of devices and participants interacting with the old gaming consoles.

Nostalgic Elements

The activity that followed the interaction with outdated video game consoles served the purpose of gathering insights on *What makes the Game Boy nostalgic?*. To facilitate this, the same live questionnaire tool from before, where participants could answer using their smartphone, was employed. The posed question was deliberately phrased in a broad and open-ended manner, allowing participants to express their responses freely without being steered toward specific aspects, such as the device's physical properties.

One could argue that all preceding tasks in the workshop served as a form of preparation for this reflection on the nostalgic elements of the Game Boy, making it the most insightful part of the session.

Tier Chart

A final task, that build upon the topic of the workshop and more importantly on the identified nostalgic elements, was a ranking activity. Several weeks after the workshop took place, I met with each of the six participants individually to have them revisit and further expand on the aspects that make the Game Boy nostalgic to them. This step also provided an opportunity to clarify any responses that were unclear from their friendship book entries.

A tier chart was chosen for the ranking method, both for its practical advantages and the reference to video game culture. Unlike traditional ranking systems that enforce a strict hierarchy, the tier chart format enabled participants to categorize multiple elements as equally important, offering a more nuanced evaluation. Participants were given 14 snippets of paper, each featuring a different aspect related to the Game Boy's nostalgic value, which they should assign to a tier based on the extent to which they felt the element contributed to the Game Boy's nostalgic appeal. The elements included were drawn both from the workshop findings and relevant literature, ensuring a diverse set of factors for participants to assess. Once they had completed their ranking, they were asked to elaborate on the elements they ranked highest (i.e., placed in the top tier titled "S" for Super) and their significance — explaining what they understood by the element

and how it contributed to their sense of nostalgia.

4.4 Workshop 2: Speculation

4.4.1 Objectives

For the second workshop, the core objective was to generate ideas how the Game Boy can be given a second life by envisioning a new use for it. The focus was on understanding how non-experts approach repurposing a device they associate with nostalgic value — what influences their decision-making, and whether nostalgia acts as a constraint in this process. To support creative ideation, elements of speculative design were incorporated. While nostalgia remained an underlying theme, it was not explicitly prompted but rather naturally emerged from engagement with a culturally significant device from the past.

Insights from the workshop served multiple purposes. First, the participants' speculative ideas directly informed the prototype developed in this thesis. Whether as fully realized concepts or as sources of inspiration, their contributions helped shape the final design outcome. Additionally, the workshop aimed to gather insights related to the second research question, particularly whether nostalgia acts as a limiting factor when searching for alternative uses. Lastly, having participants reflect on their design choices in relation to repurposing can provide valuable takeaways and lessons learned for the third research question, namely answering broader implications for extending the product life of other outdated technologies.

4.4.2 Participants

The participants for this workshop were recruited in a similar manner to the first workshop - from my circle of friends who were growing up in a time when the Game Boy was a prominent part of children's lives, specifically in the 1990s and early 2000s. This ensured that all participants had at least some familiarity with the device, even if their personal experiences with it varied. The selected participants represent non-experts, meaning they have no prior experience in modding gaming consoles or actively engaging in the repurposing of electronic devices.

The workshop included five participants, none of whom had taken part in the first session. Most of them knew each other, which contributed to a comfortable and open atmosphere for ideation and discussion. They were informed that the workshop would focus on finding a new use for the Game Boy but were not required to prepare anything in advance. The speculative nature of the activity was not disclosed to avoid influencing their approach or making the workshop goal seem too abstract or far-fetched, as highlighted by Auger [5] regarding the term *speculation*.

4.4.3 Implementation

The workshop took place in my home and was conducted in German to reduce any barriers to participation, allowing for free discussion and expression of thoughts and ideas without the constraints of a formal research setting. It was planned to last no more than three hours, with an initial aim of around two hours. The session was divided into two parts: the in-person workshop activities and an individual reflection in the form of a questionnaire conducted online a few days later.

The preparation of the materials for the workshop built upon the findings from the first workshop. Particular emphasis was placed on establishing a structured workshop story and narrative to guide participants through the speculative process. This approach was inspired by Huusko et al. [31] on facilitating speculative design in workshop settings. In addition to the prompts for the tasks, which are explained in detail below, Nintendo handheld consoles and corresponding accessories, as well as various crafting materials to encourage hands-on ideation were provided.

Time capsule

The first activity was designed to bring back memories of the Game Boy, potentially evoking nostalgia, without doing the extensive groundwork as in the previous workshop. To achieve this, participants were asked to write a note for a time capsule, capturing the Game Boy's legacy for future generations. The exact instruction given was: *Write an entry for a time capsule that captures the pop culture phenomenon that is the Nintendo Game Boy.* Participants were free to choose how they wanted to design their entry, whether as a drawing, a description of how the device worked or a depiction of a specific memory. To assist those who were having difficulties getting started, two guiding questions were prepared: Why and how should it be remembered? What memories does it evoke?

Initially, this task was not intended to generate data, as I assumed it would not add new insights beyond those already gathered from the previous workshop and literature. Instead, its purpose was to get participants thinking about the Game Boy and reflecting on why it should be remembered, preparing them for the speculative task that followed. However, the responses turned out to be very valuable, contributing to a more holistic understanding of the Game Boy's nostalgic significance.

Speculation

Inspired by the works on speculative design discussed earlier in this chapter, the speculative task of the workshop was introduced through design fiction to encourage and help with reimagining the Game Boy. The research on speculative design and design fiction in workshop settings significantly shaped this task and the way the prompt was designed. Key considerations included:

- **Structured narrative:** The task was embedded in a broader workshop story that connected the first and second activities. Aiming to create an immersive experience,

the narrative also helped guide participants through a seamless transition from the Game Boy's past to imagining its future.

- **Distinct and curious format:** To spark curiosity and make the exercise feel different from a typical brainstorming session, the task was delivered in the form of an invitation letter. Each participant received their own folded letter, marked with a fictional logo from the sender ("Ministry of (Almost) Forgotten Treasures - MAFT"), and read it individually before the speculation began.

- **Engaging and inviting prompt:** In the invitation letter, participants were addressed directly, making them active agents in the narrative. By framing them as selected experts tasked with shaping the future of the Game Boy, the activity aimed to encourage engagement and ownership of ideas.

- **Future-oriented perspective:** Rather than positioning the task as a solution to present-day problems, the scenario was explicitly set in the future to avoid limiting participant's imagination by what is possible today.

- **Neutral to optimistic tone:** While dystopian settings are often used to provoke speculation, this workshop deliberately adopted a more neutral, in some parts even humorous, approach. This consideration aligned with the nostalgic yet playful nature of the Game Boy itself.

- **Embedded values and aims:** The design fiction also served as a means of incorporating values and objectives deemed relevant in the research leading up to the workshop. This approach encouraged that the speculative exercise was not purely imaginative but also grounded in the broader discourse surrounding topics such as preserving nostalgia and creative reuse.

In line with the participatory design principle, I positioned myself as the facilitator of the process, taking-in a non-intrusive role and interfering the speculation only when questions arose. Since the ideation process turned out to be highly interactive on its own, participants repurposing ideas for the Game Boy were not formally presented or discussed in a structured format, contrary to suggestions in the literature on speculative design (e.g., [4]). Notes were taken throughout the workshop and later supplemented with insights from audio recordings of the speculative task to ensure accurate documentation of the discussion.

Reflection

Two days after the workshop, participants were sent an online questionnaire designed to encourage them to reflect on their ideas and the considerations that led to them during the workshop. In four questions they were asked to elaborate on the rationale behind their design choices and explore to what extent certain factors, such as their personal experience with the Game Boy, played a role in their approach to reimagining

[Attention Strictly Confidential]

Date: December 5, 2035
From: Ministry of (Almost) Forgotten Treasures (MAFT)
Subject: Giving New Life – Operation Second Play

Dear Specialist,

In 2035, Austria once again holds a record: the highest amount of e-waste per capita in Europe—a title we've maintained for over 10 years. While our country leads the way in collecting discarded electronic devices, it's time to move beyond just gathering them and focus on creative reuse.

The Ministry of (Almost) Forgotten Treasures (MAFT) is launching *Giving New Life*, a campaign to rediscover and revitalize the potential of old electronics that have been gathering dust in Austrian attics.

This is where you come in. We took notice of you in the past when you shared your memories of the Game Boy for the time capsule back in 2024. As part of *Operation Second Play*, we now ask you to find a new use for the Game Boy. You have the freedom to decide which elements you want to preserve or discard, and how far you want to deviate from its original purpose as a gaming console.

> **How can you breathe new life into this outdated device without losing its core qualities?**

The evaluation of the 2024 time capsule entries revealed the following aspects that define the Game Boy:

- The tactile feel of the console and buttons
- Software and mechanical sounds
- Graphics: Pixels, 2D
- Shared gaming experiences
- Specific games (Pokémon, Super Mario, Tetris, etc.)
- Physical media: Cartridges, disks
- Borrowing, sharing, and exchanging
- Longevity
- Accessories and gadgets

Let these defining characteristics of the Game Boy inspire you, and think of concrete ideas on how this retro artifact can be adapted to a radically different world. Your results can take any form, whether sketches, stories describing the new purpose, or drawings illustrating interactions.

Why Now?
In a world brimming with innovation, there's a danger of losing the charm and usefulness of earlier technologies. By repurposing objects like the Game Boy, we aim to honor materials and knowledge while creating space for sustainable innovation.

With curiosity and creativity,
Dr. Remi Nissenz
Director, Ministry of (Almost) Forgotten Treasures (MAFT)

P.S. This mission is strictly confidential to prevent people from scavenging landfills and driving up the prices of old technology.

Figure 4.3: Invitation letter which served as a starting point for the speculative design task in Workshop 2.

the device. Particular focus was placed on whether participants experienced a conflict between repurposing the Game Boy and preserving its nostalgic value.

Although nostalgia was an underlying theme in the workshop, it was intentionally not mentioned to avoid steering participants toward a specific direction. It was only in the reflection that the theme of nostalgia was brought into focus, prompting participants to consider whether and how it influenced their choices in repurposing the Game Boy. The complete questionnaire can be found in Appendix B, providing further context and details on the reflective process.

4.4.4 Personal Reflection

Reviewing the design of the speculative task, in particular the invitation letter, I discovered that some ideas did not unfold as originally intended. Although the invitation letter served the purpose well of immersing the participants in the story and having them discuss future needs and circumstances rather than the limitations of today's technology, the text also implicitly gave participants information that I had not anticipated. Two such details became apparent in participants' discussions: For one, the term "electro waste" was confusing for one person, thinking that the task was about finding a new use for broken Game Boy devices. The other misunderstanding occurred due to the framing of the invitation letter being sent from the *Ministry of (Almost) Forgotten Treasures*, which one participant understood as an institution close to the government and thus thought the concept of encrypted message exchange through Game Boys to circumvent government surveillance would not be of interest to the ministry. In both instances, the misunderstanding could be clarified without disrupting the speculations too much.

More broadly, the prompt may have been overly detailed and long, with the invitation letter providing more input than ultimately helpful. Despite the embedding of aims and values in design fictions, which is recommended by literature to help guide workshop discourses, it ended up being more elaborate than necessary. As a result, some of the participant's statements and reflections seemed to be strongly influenced by the information contained in the letter, adopting the viewpoint conveyed through the design fiction rather than forming their own opinion on the topic. The risk of distorting participant's contributions by imposing their own values and agendas is something that has been discussed in literature [13].

Finally, a reflection that has nothing to do with the course of the workshop but with thinking about the prompt in hindsight, is that the future-orientation of the design fiction might not be suitable for speculative design tasks dealing with outdated technologies. Because the different Game Boy generations are already considered old and the experiences of playing with them lay far in the past, the future of the devices is the present day. The 10 year future perspective was precisely chosen because of this fact, however, that turned out to be too little time to fully free participants from present concerns. A time much further in the future, on the other hand, might raise the question of whether people still have nostalgic feelings for the device.

4.5 Online Research

Following my online research to find inspiration for the practical part of the thesis, online comments on repurposed Game Boys were a substantial part of the methodology. Examining how repurposed artifacts are perceived by other people adds to a holistic view of acceptance and the tension regarding changing nostalgic items to make them fit a new purpose.

The focus of this research was on Game Boys which were irreversibly remanufactured to be used in a new way. This focus was chosen to specifically explore instances of repurposing, where the tension of repurposing and retaining valuable components is most likely to occur. Accordingly, it was particularly looked for critical comments, with the aim of supplementing findings from the workshop and literature with another perspective on the outcomes of repurposing. Three results of remanufacturing were examined, where the people who commented on the posts were likely, for the most part, enthusiasts, given their emotional reactions and the websites on which they were posted.

4.6 Design and User Sentiments

The practical part of the thesis comprises the development of a tangible prototype. Inspired by the ideas generated in the speculative design workshop, an outdated handheld Nintendo Game Boy console was repurposed to suite a new function or context, giving it a second life beyond gaming. In this way, the prototype serves two purposes for the research: Firstly, the physical prototype exemplifies the process of repurposing an outdated device and the ways in which nostalgia influences the process and outcome. Secondly, it is the designed artifact of the speculation, that illustrates the new use case as part of the world in which new values are being unlocked from things that have been stored away. Such materialized design fictions have the ability to represent the imaginative world they live in, prompting speculation in the viewer [21].

As a final step, the sentiments of former users of Game Boy consoles were collected, to assess whether the designed artifact is a meaningful augmentation of the original device. The target group was the participants of the first workshop, who engaged intensively with the nostalgic appeal of the console in the course of the workshop, and can, therefore, judge the artifact from this very perspective. They individually explored the new interaction of the device by interacting with it on their own without any instructions. Following the interaction, participants filled out a questionnaire of three open-ended questions, which captured their sentiments about the repurposed device as follows:

- How did it feel to interact with the Game Boy Advance SP in a new context?
- Does the new function of the Game Boy Advance SP feel like a respectful further development, or do you feel like it lost some of its original charm and nostalgia?

- If old devices could be given a second life through new functions - as in this case - would you feel more inclined to keep or reuse them? What role do your personal memories of the device play in this?

CHAPTER 5

Exploration

In conducting the methods as presented in the last chapter, a lot of detailed qualitative data was collected with regards to the nostalgic appeal of the Game Boy, how former users relate to consoles they have not used in a long time, what possible future lives of the device could look like, influences participants perceived in envisioning new uses and what aspects of repurposed Game Boys were subject to criticism. The findings are structured according to the methods that led to them, with a final section where they are brought together to outline how the exploration forms the foundation for the design.

5.1 Workshop 1: Nostalgia

5.1.1 Friendship Book

The survey responses highlighted recurring themes — such as the emotional attachment to specific games, consoles, and cultural references — while also showcasing individual differences in nostalgic experiences.

Below, the findings of the friendship book are divided into two subsections equivalent to the first two pages of the survey filled out at the beginning of the workshop which cover the exploration of participants' childhood memories, and the last page of the survey filled out at the end that touched upon the possible future of the Game Boy.

Exploring past experiences

A clear pattern emerged across participants' responses: memories of playing with consoles in the past are deeply intertwined with emotions, social interactions and specific personal experiences.

The most prominent theme is the association of recollection of playing video games with **emotions**, primarily positive ones. Experiences were described in connection to *absolute*

dedication, *fun*, *cosiness*, *freedom*, and a sense of *losing track of time*. Interestingly, one participant also mentioned *failure* as a negative emotional association, highlighting the contrast in memories.

Gaming with consoles was also often remembered in relation to **social activity**. Multiplayer experiences shaped in particular one participants memory, from trading Pokémons, to playing FIFA with friends on splitscreen and participating in an 8-player Mario Kart match. The value of the social aspect of gaming is not universally recognized however. Preferences regarding playing alone versus playing together were nearly split, with a slight lean towards playing together (3 votes) over playing alone (2 votes), while one participant enjoyed both equally.

When asked about specific recollections, participants often referred to **concrete events**, such as the excitement of unboxing a Game Boy Advance SP, a summer holiday, or playing Mario Kart on a school trip. In addition to concrete events, recollections often included **specific gaming consoles** and their defining features, such as the Game Boy Color, PlayStation 1 and the splitscreen exerience of playing FIFA.

A common theme for participants was to answer with **specific games** when asked about what they associate with playing consoles as a child. From the wide range of games mentioned in this context, it can be gathered that the specific games that hold nostalgic meaning are individual. This is supported by another question of the friendship book, where participants were prompted to write down their favorite game in their childhood or adolescence, where all games besides Pokémon and Super Mario were only mentioned once.

Further insights arise from the part of the friendship book, where participants were presented opposing statements they should choose from. While tendencies could be detected, these findings should not be understood as precise conclusions, given the binary nature of the choices. The responses indicate a strong preference for physical interaction, with all participants favoring buttons over touchpads and physical game ownership over digital libraries. When it comes to sentimental objects, opinions were split—some prefer to keep them tucked away, while others display them in their living spaces. Additionally, most participants expressed a preference for upgrading and preserving older items rather than replacing them entirely.

Outlook to the future

The results of asking participants which outdated technologies they still use and for what reasons, indicate that outdated technologies are retained both for their distinct experience and their continued practicality. Two participants value the visual qualities of older technologies, as they continue to use film cameras. One of whom further elaborated on the anticipation of waiting for film to be developed, which highlights a unique experience that modern cameras cannot recreate accurately. For another participant the motivation for using a watch is that it still functions properly and it has not disadvantages only

because it is old. The iPhone 8 remaining in use suggests that there is no need for constant updates.

These survey responses also provide insight into participants' expectations for a reinterpretation of the Game Boy. When asked what an updated version should retain, participants emphasized the importance of tactile buttons, retro look, sound and design elements attributed to the recognition value of the device. This said, there was also the opinion, that the limitations of old technologies should be considered carefully, but that also only good enhancements of modern consoles should be incorporated. One answer further suggests, that the playful aspect of the console should not be lost, saying that gamification is important.

In contrast, when asked what features would be necessary for them to use a Game Boy today, responses highlighted practical and technical improvements. Participants prioritized a bright display, rechargeable batteries, WiFi and game-saving functionality. Some participants expressed that they would still want an analogue look and old-style graphics, suggesting that a balance between retro aesthetic an updated technical capabilities would make the device appealing today.

When asked for ideas or remarks on a repurposed Game Boy, participants leaned toward practical applications. Suggestions included a power distributor and drawings related to plants, indicating an interest in functional and possibly eco-friendly adaptations.

5.1.2 Associations

The responses to the pop-cultural prompts revealed how nostalgia emerges through a variety of associations with people, places, emotions, and everyday experiences.

A prominent theme was **other people**: Family members, friends or specific individuals came into participants' minds when presented media of their childhood, highlighting the interpersonal nature of nostalgic memory.

Places also played a significant role. Participants mentioned specific locations such as "Berlin", "school" or the name of a local toy store. The mention of familiar places indicates a strong spatial anchoring of past experiences.

When asked what certain cues reminded them of, many referred to **specific activities and times**. The corresponding associations, like "weekends", "watching TV with friends" or "Friday nights", suggest that nostalgia is linked to everyday routines and recurring moments.

Emotions were also intertwined with recalled memories. The most commonly mentioned emotions were positive: fun, love, laughter, comfort, freedom. Yet there were also mentions of "boredom" in connection with using Microsoft Paint, or "stress" linked to intense Mario Kart sessions. One participant even associated bullying with a sound played, underpinning that not all memories evoked by nostalgic media are joyful and positive.

However, not all references resonated equally. One image, a screenshot of a browser game I used to play, failed to trigger any associations from most participants except my brother. It becomes evident that while some pop-cultural artifacts are widely shared across a generation, others are solely personal.

5.1.3 Playing: Observation, Notes

During the playing part of the workshop, it was interesting to observe how participants instantly gravitated toward consoles and games they had played as children, indicating a strong personal connection to past gaming experiences. After some time, a sense of curiosity emerged as well, with participants approaching consoles they had never used before, with one participant saying *"I've always wanted to try this"*, in reference to Tetris on the Game Boy Classic, just as it was bundled at release.

Social interaction also played a notable role. It was especially visible in multiplayer games such as Eye Toy, a Nintendo 64 Olympics competition, or PictoChat on the Nintendo DS. Even participants who did not previously know each other bonded over games, while those with existing connections used the opportunity to introduce personal favorites. A particularly memorable moment was when my brother proudly showed me how he finally understood the game that we could never quite grasp as children. This also highlights how people revisit games that were once associated with frustration and failure, now approaching them with a sense of nostalgia and renewed curiosity.

5.1.4 Nostalgic Elements

Participants' responses to the question *"What elements make the Game Boy nostalgic?"* revealed a multifaceted understanding of how adults reminisce their experiences with the Game Boy. To analyze the data, I applied an inductive coding approach, systematically color-coding the responses to identify recurring themes. The identification of themes was mainly grounded in the answers gathered from the workshop, however I supplemented them with topics that emerged from literature which appeared relevant to include in further analysis. This resulted in "Franchise" and "Longevity" being added to the list of nostalgic aspects, although these topics were not particularly notable in the workshop activity, but in the related work [41] [9]. Descriptive terms were found for the 14 themes, each representing an aspect of nostalgia related to the Game Boy. Some topics overlap and are not necessarily mutually exclusive, but they each emphasize different factors that may be of interest for further investigation. The topics are:

- Haptic
- Buttons
- Control
- Design of the Console
- Sound
- Graphics
- Colors
- Cartridges, Discs

- Accessories, Gadgets
- Games
- Franchise
- Longevity
- Limitations
- Game Characters

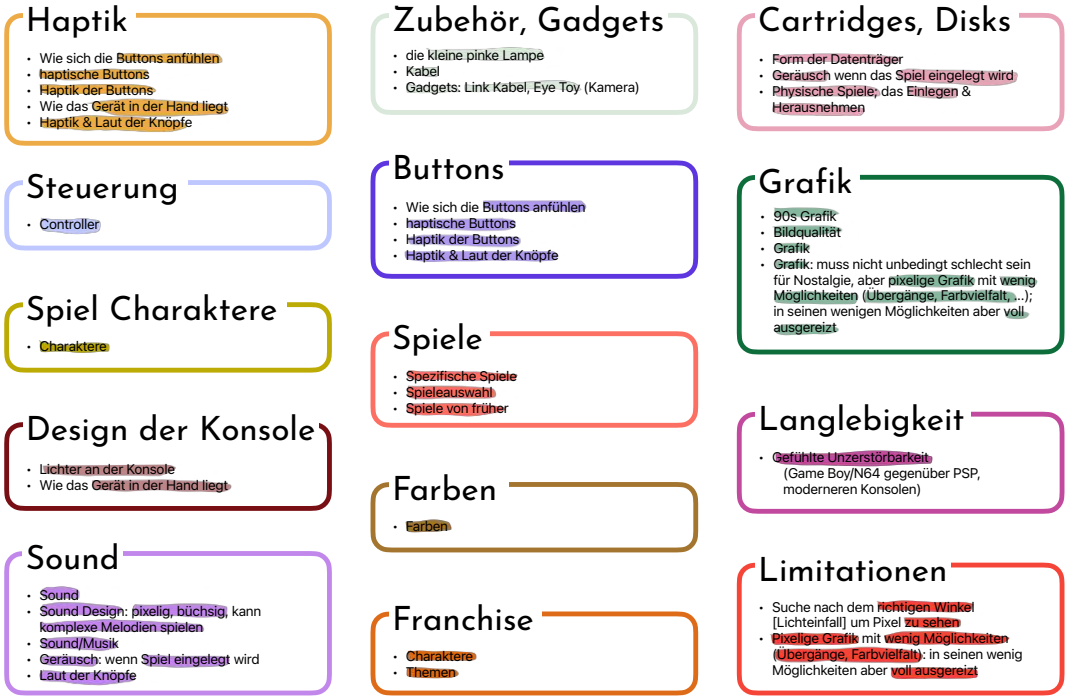

Figure 5.1: Themes of elements that contribute to the nostalgia of the Game Boy, according to participants' responses in Workshop 1.

For further context on how these themes emerged, figure 5.1 visualizes the results of this thematic analysis, listing the identified themes alongside the corresponding participant responses that shaped their formation. The following section will further enrich these findings, adding information and more detailed participant understandings of the themes.

Interpretation and Findings

The results of this workshop activity show that the nostalgia of the Game Boy cannot be pinned down to one single factor that accounts for it. The analysis resulted in diverse themes - ranging from the physical experience of the device (e.g., haptic, buttons, cartridges/disks), to aesthetic and sensory elements (e.g., sound, graphics, color), and broader perceived characteristics (e.g., longevity, technical constraints). The main takeaways from the analysis can be summarized as follows:

- **Nostalgia is mulitsensory.** The nostalgia of the Game Boy arises from an interplay of haptic, audiovisual and interactive experiences. Some perceptions are even strongly linked to memory. For example, one participant described the sound and feel of the buttons as nostalgic, while another highlighted the nostalgic quality of the sound produced when physically inserting a cartridge.

- **Once-common features are now seen as nostalgic.** Elements that were once standard and often unnoticed — such as low-resolution graphics and chiptune sounds — have gained nostalgic significance over time. While they were simply part of the Game Boy experience at the time, they are now actively recognized as defining characteristics that shape nostalgic memories.

- **Physical interaction is important.** The physical engagement with the Game Boy was expressed in various ways by the participants. Holding the device, pressing the buttons and inserting cartridges all create a tangible connection to past experiences.

- **The resourceful design is appreciated.** A part of what makes the Game Boy feel special in retrospect is the ingenuity behind its design. Despite the limited number of pixels, developers managed to create visuals that are perceived nostalgic precisely because of their creative constraints.

- **Nostalgia extends beyond gameplay to ritualized actions.** Repetitive, physical interactions - like inserting the cartridges or searching for the right angle to the light to be able to see something on the screen - seem to be an integral part of the Game Boy experience that continues to evoke nostalgic feelings.

5.1.5 Tier Chart

The findings from the tier chart ranking activity offer a deeper understanding of the relative importance of the identified nostalgic elements. Participants ranked the 14 aspects of the Game Boy's nostalgic appeal, providing insights into which elements were most significant to each participant's sense of nostalgia, while also revealing personal interpretations of their highest ranked elements.

To analyze the tier chart rankings, I assigned each tier a numerical value (S = 1, A = 2, ..., F = 7). For each of the 14 elements, the mean rank across all six participants' tier charts was calculated, an overview of the data can be found in Table 5.1. This mean value provided an indication of the relative importance of each element in terms of its contribution to nostalgia, with lower values corresponding to elements deemed most significant. The illustrated analysis from before was supplemented with the calculated scores, together with the personal interpretations and explanations of how the elements contributed to participants' sense of nostalgia. The analysis was further updated with key insights for the individual elements, providing a quick overview of the Game Boys' multilayered nostalgic appeal. The elements are ranked according to their calculated mean rank. Star icons were added to the elements ranked in the S tier, pointing out that

they were considered especially important for eliciting nostalgia. The number of stars assigned corresponds to how many participants ranked the element in the highest tier.

Element	Tier	Mean Ranking	S Tier Count
Cartridges, Discs	1,1,1,1,2,2	1,33	4
Games	1,1,1,2,2,3	1,67	3
Sound	1,1,1,2,2,3	1,67	3
Haptic	1,1,1,2,4,6	2,5	3
Design of the Console	1,1,2,2,3,6	2,5	2
Graphics	1,1,2,2,4,5	2,5	2
Game Characters	2,2,3,3,3,3	2,67	0
Accessories, Gadgets	2,2,2,3,4,4	2,83	0
Buttons	2,2,2,4,4,6	3,33	0
Control	2,2,3,3,4,6	3,33	0
Longevity	1,3,4,5,5,7	4,17	1
Colors	4,4,4,5,6,6	4,83	0
Franchise	2,4,4,6,6,7	4,83	0
Limitations	3,5,6,7,7,7	5,83	0

Table 5.1: List of elements with assigned tiers and calculated mean ranking.

Interpretation and Findings

Given that the tier chart had seven categories, most elements received scores closer to the higher end of the ranking. This corresponds to previous findings, where the mentioning of different aspects contributing to the Game Boys' nostalgia leads to the conclusion that its nostalgic appeal is multi-facet, experienced through different properties of the device. The ranking suggests that not one or two features stand out in particular, but several elements are judged to be of similar importance. A closer look at the individual elements uncovers additional results.

Cartridges, Discs (1,33)

The cartridge design and use are deeply intertwined with the nostalgic experience of the console. More than just a means of playing games, they have become an iconic symbol of the Game Boy itself. This is further strengthened by the specific shape and distinctive look that makes them easily recognizable, and the fact that the cartridges are exclusive to the Game Boy, fostering a direct link with the device.

Beyond their functional role, cartridges contribute to the ritualistic and sensory aspects of nostalgia. Participants point out the act of inserting a cartridge, the haptic experience and characteristic sound it produces. One participant additionally elaborated on the advantages of physical games compared to digital ones, noting that cartridges could be shared and borrowed. Besides the central theme of ownership, this introduces a social

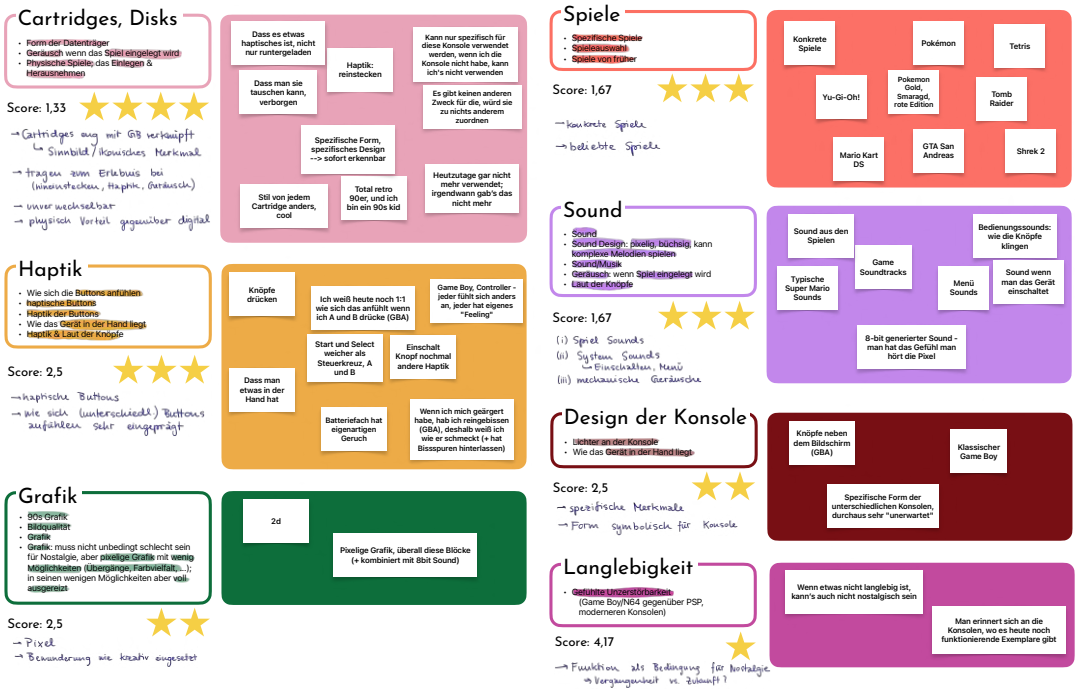

Figure 5.2: Elements considered particularly influential on the nostalgic appeal of the Game Boy, with comments of the participants.

dimension to nostalgia, where exchange and collective play are remembered as an essential part of the Game Boy experience.

Games (1,67)

Specific games also appear to play a crucial role in shaping nostalgic memories. Participants referenced well-known titles such as *Pokémon* (different editions), *Tetris*, *Yu-Gi-Oh!*, *Tomb Raider*, *Mario Kart DS*, *GTA San Andreas*, and *Shrek 2* - highlighting how individual game experiences contribute to the overall nostalgia. While *Pokémon* and *Tetris* were widely popular and symbolic of their era and different Game Boys generations, other games may hold nostalgic value due to personal childhood memories. With the game *GTA San Andreas* mentioned in this context, which is not available for old Game Boy generation but better known as desktop game, one could argue that the nostalgia may extend beyond the Game Boy, and that the Game Boy serves a touch point for broader gaming memories.

Sound (1,67)

Throughout both workshop activities, the distinctive audio characteristics of the Game Boy were a common theme. They were described as tinny and "hearing the pixels",

reflecting the 8-bit, chiptune generated sound. Participants responses can be categorized in three different types of sound:

(i) **Game Sounds:** Participants associated iconic in-game sounds (like in Super Mario) and game soundtracks with nostalgia.

(ii) **System Sounds:** The start-up sound and menu navigation also contribute to nostalgia.

(iii) **Mechanical Sounds:** Beyond digital audio, participants also found nostalgia in the physical sound of interacting with the device itself. The sound of pressing buttons or inserting a cartridge were explicitly mentioned.

Haptic (2,5)
The haptic experience of the Game Boy plays a crucial role in its nostalgic appeal, as participants recalled not only how the device felt in their hands but also the distinct tactile sensations associated with its buttons. This is made especially clear with one participant emphasizing how the *A* and *B* buttons felt different from *Start* and *Select*, and how the *power switch* had its own unique feel. It was also noted that each console had its own distinct haptic identity which adds to the finding that haptic interactions form a significant part of what makes the Game Boy experience so memorable.

Design of the Console (2,5)
The Game Boy's design is not only functional but symbolic. Its shape, button placement, and visual details make it instantly recognizable, even to those who have not used one in years. For one participant, the most defining characteristic is the unique form different Game Boy models have, making each iteration memorable in its own way.

Graphics (2,5)
Described as pixelated, 2-dimensional and typical 90ies, the visual style of the Game Boy is an important factor in its nostalgic appeal. It creates a recognizable visual language where everything is composed of simple blocks and limited (color) detail. The graphics were also mentioned in combination with 8-bit sound design, fostering the recurring theme that memories of the Game Boy comprise different senses. How things are displayed on the Game Boy has become an essential part how the device is remembered. However not as a technological constraint, but as a defining aesthetic.

Game Characters (2,67)
Popular franchises like Pokémon or Super Mario contribute to nostalgia, however the characters themselves are less emphasized compared to the games and characteristic game sounds.

Accessories, Gadgets (2,83)
Accessories and Gadgets add to the experience of the Game Boy, but their nostalgic value is highly individual. This adds a personalized layer of nostalgia, one that varies between individuals depending on what add-ons to the Game Boy they owned as a child.

Buttons (3,33) and Control (3,33)
Although they are part of the physical interaction, the elements Buttons and Control seem to be less defining compared to the overall haptic experience.

Longevity (4,17)
From participants' responses it can be concluded that longevity plays a crucial role in whether something becomes nostalgic at all. For one participant the longevity was particularly important, ranking it highest, while the overall score is rather low. This might be explained by the understanding that longevity is a prerequisite for nostalgia rather than a trigger.

The fact that many Game Boys are still functional today reinforces their nostalgic value, with one participant expressing *"One remembers consoles, where there are still functional devices today"*. Accordingly, the physical presence and functionality make it a living artifact of the past that elicits nostalgia.

Colors (4,83) and Franchise (4,83)
Whilst these elements contribute to brand recognition, they are still less immediate triggers for nostalgia.

Limitations (5,83)
Even though different responses from the previous activity highlighted that technical limitations of the Game Boy encourage nostalgia, it is ranked the least influential factor when compared to other elements. A potential explanation for this could be the disadvantageously chosen term "limitations", which suggests what the device lacked rather than what made it special. Users do not fondly remember the absence of features but instead the unique interactions and workarounds (e.g., searching for the right angle to the light because Game Boy missed backlight) that came with them, which offers a more positive framing.

5.2 Workshop 2: Speculative Design

5.2.1 A message to the future

Instead of creating a simple list of bullet points and explaining the Game for future generations, participants chose to drew a picture, depicting in detail the experience of playing with the device, how it made them feel and how it still fascinated them over 20 years later. The time capsule entries revealed how the device is remembered as an

important cultural artifact, described as *a constant of our time* or *the coolest range of mobile game consoles*. The characteristics of the device, the gaming experience and the social interactions mentioned in this activity align highly with the themes prevalent in the nostalgia workshop. Participants illustrated both the joys and limitations of the device, recalling how the lack of screen lighting or short battery life shaped the experience, often requiring creativity and imagination to fully immerse themselves in its pixel-based, black and white world. The fact that such constraints are mentioned in the context of a time capsule, demonstrates how they are a significant part of the Game Boy experience, adding to the nostalgic charm. Similar to the results of the previous method, there were multiple mentions of specific games, which strengthens the finding that games make the console memorable. Some participants further expressed their view that games back then were more innovative and thoughtfully crafted than today's graphics heavy titles, that rely on updates. One feature of the device that was pointed out by many as adding to their memories, is its portability. The Game Boy could be taken on car rides, the toilet or vacations - if you brought enough batteries. Another theme that was also evident in the first workshop, is the social aspect of the Game Boy, with recollections of playing together with siblings and friends, exchanging cartridges and highlighting the accessories to play together offline. Regarding the detailed descriptions of the experience of playing with the device, it was particularly interesting that two participants independently described *hiding under the blanket to play with the console instead of going to bed* in their time capsule entry, which exemplifies how the Game Boy created shared memories across individuals, even when experienced separately.

5.2.2 Notes from the workshop

As soon as all participants finished reading their invitation letter for the speculative task, a lively discussion about the year 2035 started, initiated by one participant who asked in the group what our world will look like in 10 years. Participants voiced concerns that reflect pressing issues of today such as war, environmental disasters like floods, and increasing surveillance. Some imaginations also took a dystopian turn, including a total disappearance of traditional interfaces with human interacting solely through voice with computers, or everyone wearing spatial computers like the Apple Vision Pro. There was also critical reflection on media habits, particularly the cognitive overload caused by platforms like TikTok and the broader culture of constant attention-seeking. Some also imagined a world with scarce resources, a thought possibly inspired by the invitation letter itself.

Discussions about the characteristics of the Game Boy largely coincide with the nostalgic themes that emerged from Workshop 1, which is why they are not expanded on again here. With the focus on finding a new use for the Game Boy however, the participants looked at the device from a different perspective and brought up features that had not been considered before. One such topic was the user interface of the Game Boy. It was discussed that the different buttons provide a universal design that is applicable for diverse scenarios where users need to navigate through a menu or control a device. With

regard to the buttons it was further said that they are beneficial in terms of accessibility and therefore open up a new user group, namely elderly people. This goes hand in hand with the predominate theme that was the apparent simplicity of the device. To the participants the device feels much more approachable in comparison to smartphones for example, the hurdle of using it is very small because one cannot do anything dramatically wrong and can even press the buttons when the device is switched off. Today technology and the user interfaces are more complex and can easily be overwhelming. That is were participants see an advantage of repurposing the Game Boy, as they can imagine that people nowadays are appreciative of simple devices that serve one distinct purpose. Throughout the speculative task the smartphone remained a recurring point of reference, both in terms of features that the repurposed Game Boy could adopt, and as a contrast to highlight Game Boys design might offer an alternative to the attention-consuming nature of mobile phones. Compared to modern-day technology participants also pointed out the Game Boy's self-reliance as an important advantage: it only requires batteries and operates entirely offline. This lack of network connectivity guarantees that the device cannot be hacked or monitored - something that people might strive for in the future.

At two moments during the workshop the tension between nostalgia and reuse became evident. This was most obvious with the comment *"They're just made for playing, what can you do?"*, that highlights how deeply the Game Boy's original purpose is rooted in participants' minds, making it difficult to imagine new functions beyond its intended use. At another point participants were exploring how the Game Boy could be used to exchange messages, but the conversation quickly shifted to newer devices, the Nintendo DS, which already offered WiFi functionality. The known features and limitations of the consoles seemed to hinder creative thinking, as participants found themselves comparing it to more advanced generations of the device rather than envisioning new possibilities.

5.2.3 Operation Second Play: Ideas

The goal of the speculative task was for every participant to come up with an idea how the Game Boy can be repurposed in 2035. Contrary to my expectations, this process was very interactive, with participants discussing their thoughts and considerations with the group rather than working on an idea on their own. The main themes of their discussions are described in the section above. To ensure that the participants had a concrete idea to reflect on in the task that followed, rather than a multitude of vague visions, they were asked to individually write down one or two concepts they liked the most. Each participant committed to an idea they had brought to the table, with allowed for a personal engagement in the reflection. The output of the *Operation Second Play* are as follows:

Device to securely exchange messages. Because all of our devices are interconnected, they are prone to being surveilled. The cartridges can be used to secretly exchange messages without the government or big IT companies noticing. A secret network of is created, only decodable with a Game Boy.

Connect people in public spaces. To counteract the development of isolation and privatization in urban areas, where people do not look each other in the eyes anymore, functional Game Boys should be installed in public spaces such as public transport, bus stations, waiting rooms and bars to bring people closer together again in a playful way. The Game Boys serve as a conversation starter and a bridge between generations, with older people explaining younger generations how to play.

Dating. In a time where everything happens digitally, including dating, the Game Boy can provide remedy. Individuals store their profiles on cartridges, which can then be brought to designated locations for others to browse. When someone expresses interest, the Game Boy plays a sound to help the potential match identify one another. To break the ice and test their connection, the two can play a game together.

Control device for different applications. In the future, resources will be scarce and existing products will have to be reused. The Game Boy can be repurposed as a control unit for various devices, as a TV remote, a controller for hospital beds or operating cranes.

Geocaching information on cartridges. The new approach to Geocaching, Geocaching 2.0, uses the cartridges to store information of further Geocaches.

Besides these five concepts, participants also discussed other solutions in the course of the speculative task, including repurposing the Game Boy as a crypto-wallet, a smart home remote and a physio device for the fingers. The ideas presented above reflect the topics that emerged in the discussions and the characteristics that make the Game Boy feel nostalgic to most people. The first idea incorporating the advantage of not being connected and thus not hackable, the second idea exploiting Game Boys ability to bring people together, the third idea also building on the social aspect of the device, the fourth idea making use of the universally design interface and the haptic buttons, and the last idea focusing largely on the cartridges. What all the ideas also have in common is that the Game Boy retains a large proportion of its original design and operating principle. The extent to which nostalgia influenced this decision is clarified in the reflection that follows.

5.2.4 Reflection

The responses to the questionnaire offer valuable insight into the participants' considerations and the thoughts process behind their concepts for giving the Game Boy a new purpose. The findings reveal that personal memories of the console can both be inspiring and hindering in envisioning a new use, that the physical properties of the device should remain as they are and that sustainable factors are of great importance in repurposing decisions. The four different topics that were investigated are explored in more detail in the sections that follow.

What is kept from the original console

Most of the answers show that the participants retained the hardware of the Game Boy in their designs. A reason mentioned for reusing the hardware as it is, is that it produces the least waste, highlighting sustainable concerns of former users. Two participants expressed that the decision to keep the hardware as intentional, supported by the well-placed buttons and the display, and the functionality (of the directional pad) that can be easily translated into the real world - which they see as beneficial for reusing the device for different purposes. Another component that was explicitly mentioned are the physical cartridges, which should differ to the original ones only in the content that is stored on them (e.g., not a game but a dating profile). Besides physical elements, participants also reflected on immaterial characteristics, saying that the fun of playing, the local function, that obligates people to meet, and the portability were important for them to retain. Three participants highlighted the shift in context that was an essential part in their idea - keeping most of the parts of the Game Boy as they are but setting the device in a new context while retaining the playfulness. One of those responses referred to public spaces as a new context for the Game Boy, where the Game Boy as a whole should remain as it is and continue to be used for playing games. In the participants' perspective it would be a pity to take the Game Boy apart when it still works properly, further saying that such *retro devices* become trends all the time anyways and that playing with these consoles is still fun.

What influenced the decision making

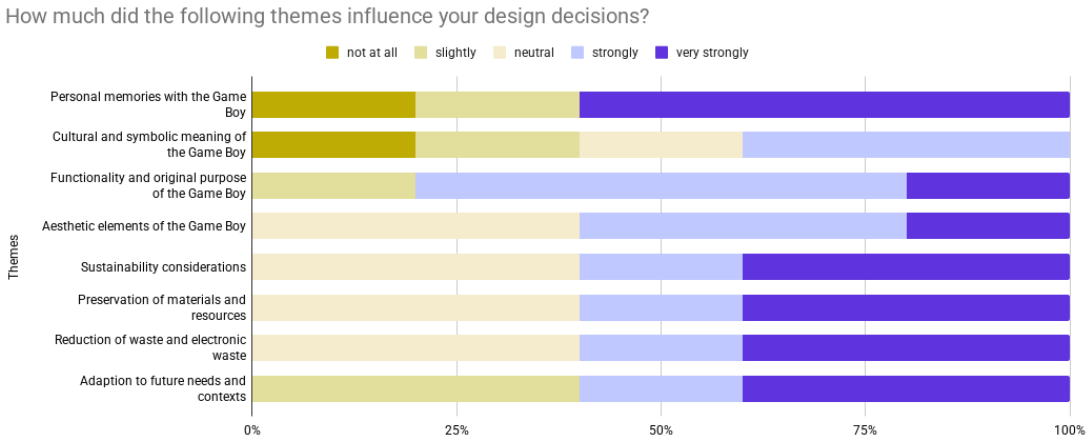

Figure 5.3: Stacked bar chart showing the distribution of responses for each element. The elements represent potential influences on design decisions and levels of influence were defined as *Not at all*, *Slightly*, *Neutral*, *Strongly* and *Very Strongly*.

The analysis of the responses to assessing different themes and their respective influences helps to understand the priorities and drivers behind participants' design decisions. The

stacked bar chart 5.3 illustrates the distribution of responses for each theme, highlighting the varying levels of influence participants perceived in the process of finding a new purpose for the Game Boy.

Personal memories seem to play a significant role in participants design decisions, with the majority expressing that they were very strongly influenced by their past experiences with the device. Regarding the **cultural and symbolic meaning** of the Game Boy, a division in participants' perceptions is visible - two found it significant, while the others were not influenced by the cultural value that is attributed to the console or felt indifferent. The **original functionality and purpose** of the Game Boy had a strong impact on most participants, suggesting that concrete properties of the Game Boy are defining to some extend how it can be repurposed. This might indicate a limiting factor for thinking of new ways to use it. Opinions on the significance of the **aesthetic elements** range from neutral to positive, however this theme did not resonate as strongly with the participants as other factors. **Sustainability considerations**, **preservation of materials and resources**, and **reduction of waste and e-waste** were all assessed in the same way. Looking at the individual responses to these themes revealed that all participants rated the three aspects as equally significant or neutral in terms of their influence on the design process. What can be outlined as environmental concerns is attributed an overall strong influence, although answers were fairly divided. Nevertheless it can be gathered that environmental responsibility is a motivation for many in their design. Lastly, more than half of the participants considered **adaption to future needs and contexts** to a high degree in their designs, while others were only slightly influenced by it.

Tension between preserving nostalgia and repurposing

The balancing act of preserving nostalgia while finding a new use for the Game Boy was perceived very differently by the participants. While two voices expressed that they see an advantage in using a familiar artifact associated with positive memories in a new context, three responses adopted a more nuanced perspective, saying that it comes with great challenges or that a use besides gaming is hard to imagine.

Regarding the positive assessments of nostalgia and repurposing, it was highlighted that the nostalgic value attributed to the Game Boy is a motivation for using the device - also for different purposes. Using a repurposed device, that might only have the shell of the original product, can evoke positive memories, which are also the reason why one does not want to dispose of it in the first place. Another participant took it further and suggested that the Game Boys positive meaning can be exploited to help people in difficult and uncomfortable situations when it is introduced in such contexts.

The more critical views, on the other hand, consider the tension of the past and the future of the device as hindering or at least challenging. One of the participants who had this stance explained that due to the nostalgic feelings many people have towards the Game Boy, the repurposed artifact should be designed carefully so as not to destroy its

reputation through negative experiences. Two other responses experienced the gaming aspect of the device as being hard to neglect. One participant emphasized that the Game Boy is well thought out for the purpose of gaming and thus it is difficult to find a new use, this, however, did not stand in the way of thinking about new ideas for it. The second response states that they never experienced the device for something else apart playing games and accordingly they perceived the balancing act as challenging, as the device is highly associated with gaming. This participant further elaborated that nostalgia resonated with this tension of envisioning a different use as well, highlighting that due to emotional attachment they could never take apart their Game Boy - only other devices, if there were a surplus of them.

Influence of personal memories

The question on whether personal memories of the Game Boy were inspiring or limiting in envisioning a second life for the device, revealed that people construe the meaning of nostalgia differently. Three of the participants responded that they were inspired by their memories and experience, one participant perceived them as hindering and one participant was neutral about it. Among the three who felt inspired, two expressed a shared motivation to bring the positive recollections of the device into the present or future. The third participant mainly remembered the Game Boy for the buttons and the haptic interaction, and found it correspondingly stimulating to find new possible uses from this point of view. The one person who was neither inspired nor hindered by personal recollections, pointed out that the aspects that they associate most with the Game Boy - the games and the fun factor - did not play any role in finding ideas or thinking out of the box. The only response which experienced a hindering influence of their memories, explained that if they did not make all those memories in their childhood, it would possibly be easier for them to find a new usage. They added that the *magic* of the Game Boy would be lost without the game-character.

5.3 Online Comments

The comment sections of posts on remanufactured Game Boys reveal that some people are very emotional and strict about original parts of the device being "destroyed" in the process of making them fit a new purpose. While only negative or critical comments were of interest in this research, it is important to note that positive remarks on the reimagined Game Boys were predominant in two of the three examples that are described below, praising them for their creativity and succeeded implementation.

In three examples the critical voices of enthusiasts about leaving certain components of the Nintendo console untouched were evident. A similarity that sets them apart from other mods, is that that they go beyond "upgrades" to the devices, like replacing the screen or adding rechargeable batteries, and remanufacture the console in a way that it cannot be used like the original console anymore. They include a smart home control

remote posted on the reddit website [1], a speedometer published as a short form video on YouTube [2], and a modified Game Boy Advance SP also published on YouTube [3]. In the smart home remote, a microcontroller was placed inside a Game Boy Classic shell, with the new project only using the shell of the original device. For the speedometer, a small speedometer was put inside a Game Boy Color shell, with adaptations made to the shell, such as drilling a hole for the cable and cutting of parts of the back to make the speedometer fit. In the third example, a Game Boy Advance SP was taken apart and the internals were put into a new shell, which changed the form factor of the device to be hingeless.

The smart home control had different users questioning what the creator of this device did with the internals, hoping they were broken and only then would it be okay to use the shell in such a way. People expressed their sadness about the loss of another Game Boy, claiming the creator ruined the Game Boy for this remote. In the speedometer comment section on the other hand, users were less concerned about the internal parts of the Game Boy Color, but the shell that was used to equip the speedometer with a new housing. A large number of users criticized, that an original shell was used for this purpose, stressing the *Original Equipment Manufacturer* property of it, that they are not produced anymore and therefore limited. Many suggested that a replica shell could have been used instead, which can be bought for cheap. Others said that the shell should have been used for a working Game Boy Color that needed a new one. The overall sentiment of the people who commented negative things was that the shell, some even say the whole Game Boy, was destroyed by this remanufacturing. Some comments are also emotionally charged, saying that "it hurts" seeing the shell ruined like this. The criticism of this projects is twofold: for one, the Game Boy being damaged, contributing to console extinction as one user put it, and secondly, the implementation of the project, people disapproving of it because it is unnecessary in their opinion or because they consider the repurposing not done properly. As with the other example, there were also mentions of the motherboard hopefully being saved or used. The comments on the video showing the process and the outcome of fitting the Game Boy Advance SP electronics in a new housing, confirm that people care about certain design properties of the original consoles and do not like to see them neglected. People who commented expressed their disapproval of the design by stating that the hinge was the best part about the console, how they could never do this and that it sad to see the device taken apart and the shell being replaced with something less valuable.

5.4 Takeaways for Design

The participatory user research offers valuable insights into the nostalgic appeal of the Game Boy, how former users envision a new purpose for the device and the significance of

[1] https://www.reddit.com/r/homeassistant/comments/e6ziih/made_a_homeassistant_gameboy_remote_control/, Accessed: 04.05.2025

[2] https://www.youtube.com/shorts/xpzBkkCetxQ, Accessed: 04.05.2025

[3] https://www.youtube.com/shorts/ZwFKttTzTSk, Accessed: 04.05.2025

past experiences on the design process. Both potentially positive and negative effects of nostalgia on the repurposing of the retro Nintendo console have been identified, leading to the conclusion that designing an artifact that aims to satisfy people who associate fond memories with the device, is a balancing act. This tension forms the basis for the prototype developed in the next chapter, which will try to take into account the favorable aspects as much as possible while hindering perspectives will shape the process additionally. In particular, the following findings have been considered to be relevant for the design, organized into four superordinate topics.

Aspects the Game Boy is remembered for
The elements that contribute to how the Game Boy is remembered today and that illustrate what the experience was like playing it as a child, have been discussed in detail in this chapter. What was particularly noticeable in participants' reminiscences, was how they described the Game Boy not just in terms of its physical design, but through the feelings, habits, and meanings attached to using it. The physical qualities people feel nostalgic about can be directly adopted for the design of a repurposed Game Boy, as they indicate which elements should be kept from the original. Accordingly, the findings suggest that elements such as cartridges, sound and graphics technologies should be incorporated in the prototype or resemble the original in order to fulfill the multi-sensory nostalgia. For it to be recognized as a Game Boy modification, it should further retain further design elements such as the button layout, shell or form factor. One of the most significant aspect Nintendo retro consoles are remembered for is, however, gaming. Which had people expressing that some kind of playfulness should be retained in a repurposed Game Boy. Contrary to the tangible properties, broader experiences people associate with the Game Boy cannot be as directly translated into a new design. This includes for example rituals that might emerge from technical limitations or highly personal memories. Throughout the workshops participants further showed their appreciation for social interactions the device reinforces, the portability and that it operates entirely offline - aspects which will not necessarily elicit nostalgia themselves if incorporated without any recognizable design elements of the Game Boy, but they are still worth considering in the final design to add to the whole picture.

Properties the Game Boy has to offer
In the speculative design workshop, where participants looked beyond the nostalgic elements and tried to determine potentials for adaptations, different features were identified which can be exploited to make the Game Boy suit new purposes. One of the most striking argument was the universal design of the user interface the different Game Boy generations have to offer. The buttons are deemed to be applicable for different uses including real-life scenarios where something needs to be controlled spatially. The buttons further ensure a high affordance, users likely know how to interact with the device because of its design. This adds up to participants seeing value in the simplicity of the device. Two other factors contribute to the advantages of the Game Boy for future uses, which are portability and self-reliance. In the workshop it was pointed out that

handheld gaming devices can be taken everywhere, one is not tied to a certain location to use it. The fact that no additional component or connection is needed for the device to work further supports the portability.

Outlook to present and future contexts
The reflection on the speculative design process has shown that participants were predominantly guided by personal memories and environmental concerns in the ideation for new uses for the Game Boy. Some participants expressed that they see the potential of nostalgia to bring something positive to the present or future. The repurposed device could represent a tangible connection to past experiences. Regarding the field of application of the repurposed device, it can be gathered that both practical and fun uses for the Game Boy are conceivable for former users, although, according to some opinions, the essence of the device will be lost if it is not given a playful facet.

Challenges and hindering factors
Through the extensive exploration of nostalgic appeal and thoughts accompanying the search for new purposes, a lot of factors unveiled that could potentially hinder the acceptance of a repurposed Game Boy and discourage people to participate in remanufacturing activities themselves. One of the most apparent theme in this regard was the game character of the console being an essential part of its value, and the *magic* of the Game Boy being lost if it was not used for playing games. In the eyes of many, despite everything the Game Boy has to offer as an interaction device, it is still best used in a gaming context. Another challenge lies in designing an artifact that lives up to the reputation the original device has. Many people recollect fond memories with the Game Boy and the newly created device should acknowledge that and should not ruin these experiences. Given the multifaceted nostalgic appeal of the Game Boy and participants' reflection on future uses, the design of the repurposed artifact should retain different recognizable design elements (such as the shell, form, and cartridges) in order to elicit nostalgia. The online comments examined support this finding, as they demonstrate that some people are very emotional about individual components, such as the original shell. The fact that original Nintendo Game Boy components are limited as they are not produced anymore makes them all the more valuable and prone to criticism of enthusiasts if destroyed in the process of repurposing it. Especially, changes to the console or individual parts, that cannot be reversed, can cause such emotional reactions. Another tension arises from the Game Boy being considered a living artifact of the past, that accomplishes to evoke nostalgic memories precisely because there still exist many functional copies. The longevity and existence of the device being a prerequisite for nostalgia points to the question of the extent to which changes to the device interfere with this view.

CHAPTER 6

Design

In this chapter, the design part of the thesis is presented. To follow on from the results of the exploration, it is first explained which idea of the speculation is selected to be developed into a tangible prototype while taking into account other findings from the research leading up to the design, such as the extent to which nostalgic elements can be incorporated into the prototype and whether interventions prone to criticism can be avoided. After illustrating the concrete implementation of the prototype, with references to tools and resources used and found helpful, the users' perceptions are discussed in order to clarify if the created design artifact meaningfully augments the Game Boy.

6.1 Choosing One Idea

Moving from exploration to design, the ideas generated in the speculative design workshop served as a starting point for the design of the final prototype. The five ideas, alongside the discussions of the speculative task, were assessed based on their feasibility, integration of features and elements important to former users, potential sustainable implications, and availability of inspiration - if and how similar projects have already been realized. Regarding the potential sustainable implications, it was considered whether the repurposed device would be useful for a longer period of time and if it could replace a device that would have been bought otherwise to fulfill its function.

As a result, the chosen idea to be developed into a functional prototype is a **smart home remote**. This concept can be understood as a variation of a workshop outcome, namely the remote to control different things such as televisions or hospital beds, which was inspired by the buttons of the Game Boy whose functionality suggests being translated to control real-world subjects. However, the idea of repurposing the gaming console as a smart home remote was also brought up in the discussion of the speculative task, but the person who mentioned it followed another idea in the end. The smart home remote concept meets the guiding criteria that I determined for the design artifact as follows:

For one, it introduces a new function, augmenting the gaming purpose for which it was originally designed. Further, repurposing the Game Boy to be used as a smart home remote serves a practical purpose, which participants of the first workshop highlighted as being important to them. The preservation of nostalgic elements can be aimed for to a high degree, depending on the concrete implementation. The feasibility of the project in the course of this thesis is indicated by the fact that online examples can be found of people using retro Nintendo consoles to control things in their homes. Much like the findings of studying Green DIYers and modding communities demonstrate (see section 3.2.3), the Internet has proven to be a good resource for finding inspiration and instructions, which finally convinced me that I could realize this project. The most decisive factor for choosing this idea over the others, however, was that the remote is a device that can be used instead of buying new. Most smart home systems do not come with a remote, but instead, the smartphone should be used to control the smart components. If a remote is wanted by the user, they would have to buy this component additionally. As an alternative to this practice, people could repurpose outdated devices they already own but do not use anymore to perform this function, as demonstrated in this chapter using the example of a Game Boy.

In addition to the arguments outlined above, the concept of a smart home remote aligns with the topic of this thesis in another important way: its field of application is the personal home - a place of memories. As a study by Petrelli and Whittaker shows, family homes are full of individual and collective memories, with inhabitants intentionally staging objects related to memories, serving the function of preserving and reinforcing those memories [42]. Accordingly, taking into account that some of the most highly valued objects in the home express personal memories, a repurposed Game Boy providing the function of a smart home remote can both support and benefit from this emotional connection, as attachment significantly contributes to a product's perceived useful life.

6.2 Prototyping

For the design and implementation of the prototype, one particular project served as a reference, which has an important advantage over other solutions namely that it does not "destroy" the console for its original purpose. The reference project is the *Wireless Game Boy Remote Control* published by the user 3DSage on YouTube [1]. The video shows the idea and process of repurposing a Game Boy Advance SP into a remote that can switch three different devices in the home, which do not have smart home capability integrated, on and off by using an infrared emitter and receiver, and motors. A custom Game Boy Advance program is written on a cartridge that displays three icons representing the different devices that can be controlled. A light-dependent resistor is mounted on the top right corner of the screen and connected to a compact microcontroller. This setup allows the system to detect a sequence of light pulses, which it interprets to determine

[1] https://www.youtube.com/watch?v=9TFHx1pvRuo, Accessed: 04.05.2025

the target device. Once identified, the corresponding device is activated via an infrared signal, prompting a motor to turn it on or off.

For the prototype developed in the course of this thesis, which can be seen in Figure 6.1, I adopted the idea of attaching a light resistor to the screen of the video console so that it functions as a remote control for things in the real world. In my case, the repurposed Game Boy was intended to control smart light bulbs I already owned, which minimized the need of additional resources to realize this project. Unlike the reference project described above, the light bulbs come with the advantage of having smart home capabilities built in, through communication via the Matter protocol.

The concept of the remote control allows for the repurposing to be entirely removable, augmenting the original device to be used for a different purpose through a new "add-on". By adopting this approach, the prototype can be allocated in the field of parasitic or piggybacking design, as it makes use of an established system (as in piggyback prototyping) and at the same time is dependent of the host (as in parasitic design) [23][48]. In the following sections the individual components of the prototype are described in detail.

(a) Game Boy displaying the start screen.

(b) Custom cartridge with the title "Light Boy".

Figure 6.1: The developed prototype.

6.2.1 Game Boy Advance SP

To realize this project, I chose the Nintendo Game Boy Advance SP as the console that should be repurposed. This has both practical and personal reasons. For a start, a key criteria was that I owned the console, as I wanted to illustrate the example of repurposing an outdated technology that is not used but tucked away in a drawer as genuine as possible - meaning that I did not want to buy a *new* Game Boy console second hand but use one from my personal repertoire. Of the consoles that included, the Game Boy

Advance SP is the one console I am most nostalgic about because it was the first console that I got and did not share with my brother.

Compared to the other consoles I had available, using the Advance SP to repurpose it as a smart home remote had practical advantages. Particularly for the implementation that depended on the differentiation of bright and dark pixels, the fact that it has a lit screen was deciding to use this device. However, the lighting of the display still posed a problem, because the model of Nintendo Advance SP that I owned was front and not back lit. In the project that served as a reference, the model AGS 101 was used, which is the newer version of the Advance SP featuring a backlit screen. Starting the development of the prototype, it was therefore uncertain whether the capabilities of the Game Boy Advance SP AGS 001 I wanted to use would be sufficient for the light resistor to recognize differences between black and white pixels.

6.2.2 Microcontroller

Essential for the project was a small computing device that was capable of processing sensor data and communicating with a smart home system. In the ESP32, with integrated WiFi capabilities and a built-in screen, I found this key criteria combined in a microcontroller. The ESP32 was flashed with MicroPython firmware and programmed using the uPyCraft IDE. Additional components needed were a light dependent resistor (LDR), a button, a potentiometer and a rechargeable battery. In Figure 6.2 the ESP32 and connected component can be seen.

The light resistor is needed for the core functionality of the prototype: reading light intensity values to detect patterns in signals displayed on the screen as alternating white and black pixels. When white pixels are displayed, the value that the LDR measures is higher compared to black pixels, thus, in defining a suitable threshold, signals can be captured with the microcontroller. A signal is defined as a sequence of light pulses, where "On" periods correspond to increased brightness (i.e., white pixels displayed), and "Off" periods correspond to darkness (i.e., black pixels). Each signal consists of two On pulses separated by an Off period. Once a sequence ends (i.e., the total pulse count is above a certain value), its pattern (i.e., pulse count of On and Off periods) is compared to a set of predefined patterns. If it matches one, a specific action is triggered, such as turning on a light bulb. More precisely, the actions include setting the brightness and color of different LED bulbs, which are executed by sending HTTP requests to Home Assistant, which is described in section 6.2.4. Details about the implementation of the microcontroller can be found in Appendix C.1.

The other components mentioned, such as the OLED screen, button and potentiometer, are used for debugging and calibration purposes. Because ambient light highly influences the measures of the LDR, it is crucial to calibrate the threshold that is used to differentiate bright and dark pixels with every use of the device. Pressing the button, it can be switched between three modes of the system: (1) the WiFi connect, (2) calibrating the threshold and (3) pattern recognition. The screen displays information based on the current mode,

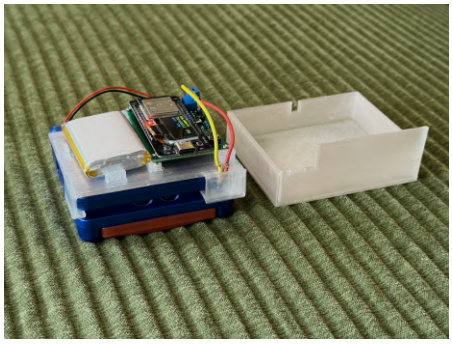

Figure 6.2: Prototype with removed cover to show the inner workings.

namely the established WiFi connection, current threshold and light intensity value, and the recognized sequences of pulses. When the system is in the second mode, turning the potentiometer knob adjusts the threshold.

6.2.3 Custom GBA Cartridge

For the purpose of having a user interface to control lights in the home while keeping all the original hardware and software of the Game Boy, a custom Game Boy Advance ROM was programmed and flashed on a physical cartridge. Figure 6.1 shows the physical cartridge with the custom program "Light Boy" on it. A YouTube video [2] and a linked GitHub repository [3] served as the starting point for the implementation, which provided valuable resources and a basic project structure for getting started with writing C code for Game Boy Advance games. The starter project by the user 3DSage implements Mode 5 graphics with double buffering and 15-bit colors. The graphics are based on 120×80 resolution and scaled to fill the screen, while the frame rate is throttled to 15 FPS for consistency. A simple chiptune engine allows to play music based on defined notes. To generate graphics in the correct file format, a converter [4] was used to create C files from bitmaps.

Development was done using devkitPro [5], which provides toolchains for homebrew development, among others Game Boy Advance specific toolchains. The project template [6] from devkitPro was adopted for its project structure and Makefile. The project was compiled using `make` inside an MSYS2 environment, producing a `.gba` file. This ROM was then flashed onto a rewritable cartridge using the BennVenn Joey JR [7], enabling physical deployment and interaction on a real Game Boy Advance SP. Further details of

[2] https://www.youtube.com/watch?v=6ecgELrwAnQ, Accessed: 04.05.2025
[3] https://github.com/3DSage/GBA_Mode_5_Starter, Accessed: 04.05.2025
[4] https://gbadev.org/tools.php?showinfo=147, Accessed: 04.05.2025
[5] https://devkitpro.org/, Accessed: 04.05.2025
[6] https://github.com/devkitPro/gba-examples/tree/master/template, Accessed: 04.05.2025
[7] https://bennvenn.myshopify.com/products/usb-gb-c-cart-dumper-the-joey-jr, Accessed: 04.05.2025

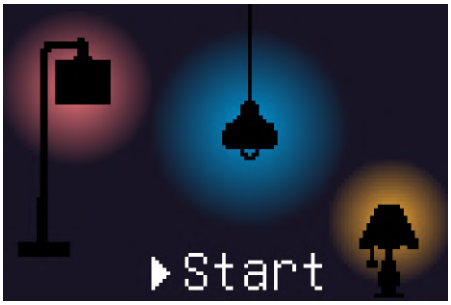

Figure 6.3: Start screen of the developed Game Boy Advance program.

the implementation of the custom Game Boy Advance program can be found in Appendix C.2.

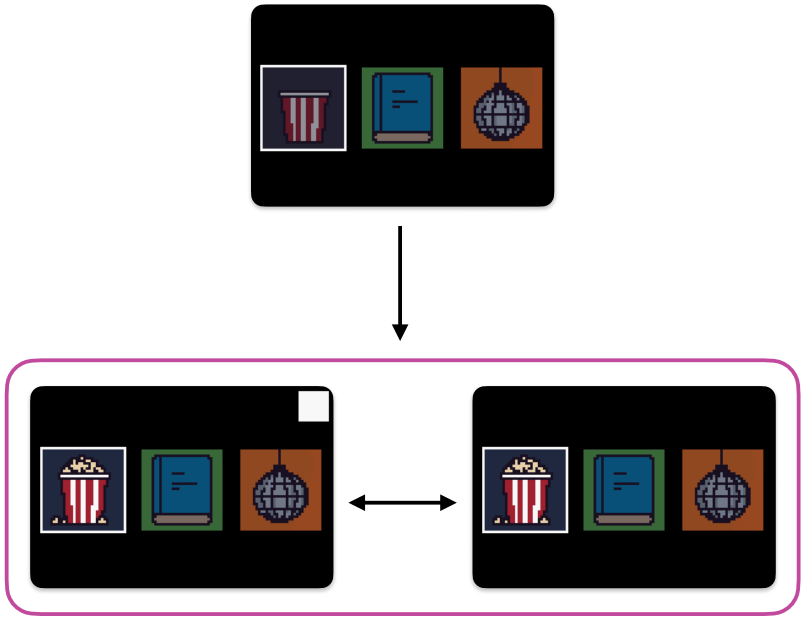

Figure 6.4: Main user interface. By selecting one of the three icons, the icon changes to a selected state and a signal is displayed in the top right corner, consisting of alternating white and black pixels.

The initial idea of the program was to use the d-pad as follows: up and down control the brightness, left and right the color of a selected light. The interaction suggests that changes in the light settings happen instantly, users would potentially press the brightness increase or decrease button multiple times and would be confused if they do not see any changes right after pressing the button. However, because the displaying of the signal takes some time to allow for the differentiation of several signals, the latency is quite

high, and the effect on the light setting happens only after approximately 4 seconds. As a consequence, it was decided to implement the user interface as a menu for navigating and choosing between three different light settings, as seen in Figure 6.4. For further reference, Figure 6.5 shows the icons for the light settings.

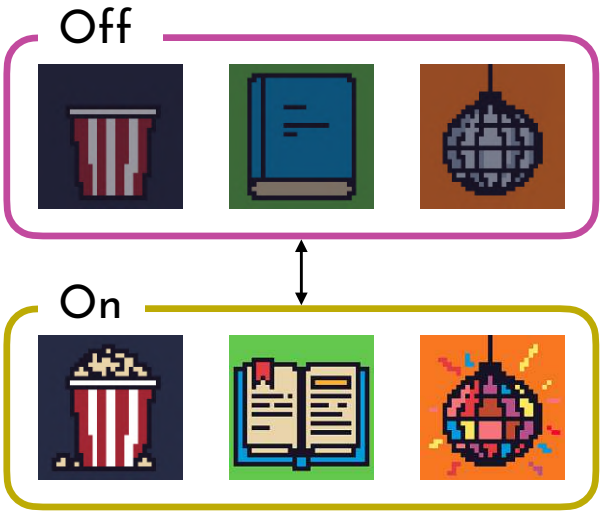

Figure 6.5: The three different light settings which can be activated for three different purposes: watching a movie (popcorn bucket), reading (book) and party (disco ball). For each light setting, there are two different icons that indicate whether the setting is on or off.

6.2.4 Smart Home Control

For the Smart Home component, I set up a virtual machine on my Windows PC to run the Home Assistant operating system. I installed three LED light bulbs capable of changing color and brightness in my home, that operate hub-free via WiFi, and communicate with the home assistant via matter protocol. The home assistant was used, as it offered a RESTful API [8] for changing individual light states. When the ESP32 captures a signal from the Game Boy, which corresponds to one of three predefined light settings, it makes three POST calls to the API to set the color and brightness for each light bulb.

6.2.5 3D Printed Casing

In order to connect the individual components compactly in one unit, a housing was designed that takes into account the dimensions of the individual parts. The microcontroller, battery and light resistor fit tightly into the case, so as not to make the add-on

[8] https://developers.home-assistant.io/docs/api/rest/, Accessed: 04.05.2025

bigger than it has to be. The case is 3D printed with transparent filament, referencing the aesthetic of technology from the time when the Nintendo device was launched. The printed case slides onto the Game Boy Advance SP's top part and is designed to be as little intrusive as possible, covering only a small area of the screen with the component that holds the LDR. This makes it easy to remove and attach the add-on, allowing the original state to be restored without complex manipulation.

6.3 User Sentiments

The overall reception of the prototype was very positive. The users described the experience as fun, exciting and familiar. A nostalgic feeling was expressed by several users, saying that interacting with the device reawakened their childlike curiosity, that the excitement was similar to being a child and starting a new game, that it made them discover new fascination for old and familiar charm, and that both the menu and the start screen instantly evoked a retro feeling, as the aesthetic reminded them of their childhood. Participants also highlighted certain elements of the prototype, such as the handling being easy to understand and intuitive, and the icons being lovingly designed, sparking interest what they would reveal when selected. There was also the mention of the experience feeling unfamiliar, because of the influence the device has on the real world (changing the lights in the room). Another more nuanced response referred to the functionality of the device, stating that it was not very responsive and slow. The same person who expressed this also pointed to the experience as being familiar and nostalgic however, which suggests that the positive and nostalgic appeal does not compensate for potential shortcomings compared to modern technologies.

Regarding the question of whether the new function of the Game Boy Advance SP feels like a respectful further development, all five participants answered in the affirmative. They elaborated on the device being a good mix of practical use and fun, a great way to maintain the charm and a "level-up" to the original console. The functionality being expanded to everyday life is the reason why one participant saw it as a respectful further development. Another participant stressed that it is not only a respectful, but a dignified development. Different features were mentioned by the users to underpin how the prototype accomplished to retain the original nostalgic feel and charm. These included the design, the haptic, the sound and the pixel graphics. One participant was particularly specific that the charm is not lost at all, as the feeling is exactly the same as recalled from memories. Nonetheless, the person expressed that they were not sure if they would use this device, although they consider it a great solution. The re-visiting of past times was what stood out to one user, who said: *"It feels like breaking through a timeline - perfect meeting between my 90ies child self and mid-30s boy now"*.

As to whether they were more inclined to keep and reuse old devices if they were given a second life through a new function (as exemplified in the prototype), every participant agreed. The descriptions of the reasons and influencing factors were diverse. For one person, it is generally considered to be favorable to find new uses for old things. Another

participant said it would not only motivate them to reuse old devices, but that seeing what can be made out of a Game Boy also evokes curiosity. Sustainability was an important factor for one participant to reuse retro objects, along with the memories of childhood days that such inventions would symbolize. One participant even expressed that added functionality to breathe new life into consoles would be a reason to buy them. There were also remarks about prerequisites from two participants, one being that the functionality must work in exactly the same way and the other one points to the reuse of old devices needing to be easily accessible. The former implies that nostalgia does not necessarily make up for functionality, i.e., a smart home remote should function as one would expect a smart home remote to function.

The significance of personal memories on incentives to reuse old devices was perceived similarly by all but one participant. The majority expressed that their personal recollections play an important role. One participant elaborated that they generally attribute emotional value to their material possessions, which is especially significant in moments of clearing out, where emotional value is decisive whether something is kept or not. Another person stated that such inventions would help keep memories alive, that would otherwise fade (*"out of sight out of mind"*). Two responses were similar in terms of the added value that reused objects would have, precisely because of personal memories. They argued that the emotional value could not be found with any other device, and that it offers more charm compared to other *smart remotes*. The one answer that stood out from the others reflects the persons indifference about personal memories with regard to the reuse of old things. They explained that they also see used objects bought second-hand as an opportunity for reuse because they are primarily interested in the retro charm (not the personal connection), implying that the object stands for a certain period in time.

CHAPTER 7

Discussion

The following discussion brings together the insights gained from the exploration and design, using existing literature to reflect on the findings. In answering the research questions, the first three sections highlight the new knowledge created through the project, including the potential and limitation of utilizing nostalgia for repurposing, a design artifact demonstrating how longer use can be achieved through repurposing and implications from the process for other outdated technologies. The remaining sections describe the contributions and limitations of the project and highlight topics that may be of interest to future research.

7.1 Nostalgia for Product Life Extension

The use of nostalgia as a means to help prolong the life of outdated technologies has been explored in several stages in this thesis. The focus of the research was on the different generations of the Nintendo Game Boy, serving as representative examples of a technological device that is largely not used anymore and oftentimes stored away somewhere, although it offers great potential for reuse. To start with the exploration, it was of particular importance to determine what constitutes the nostalgic appeal of the Game Boy. It was found that the nostalgia associated with the Game Boy is wide-ranging and extends beyond simply recalling a childhood device long forgotten. Participants reminisced about the feelings the console evoked, habits in their interaction with the device, meanings they attached to using it and specific design elements and properties of the Game Boy. These findings were translated into a tangible prototype as a way to showcase how the nostalgic appeal can be harnessed for repurposing, and as an effect for extending the product life of the device. The prototype, a Game Boy Advance SP made into a smart home remote, was then presented to people who remembered using the console for gaming more than 20 years ago. It was examined how they perceive the

invention, as to whether it lost its nostalgic appeal or achieved to be a respectful further development of the original device.

Taking these findings together, the first research question of this thesis can be answered: *How can nostalgia be effectively utilized to find new ways of repurposing and extending the lifespan of outdated technologies in sustainable and innovative ways?*

The detailed memories and descriptions of the Game Boy by the participants of both workshops suggest that people still care about the device. This is also reflected in literature with modder communities and collectors, who actively engage in keeping the legacy of retro video consoles alive [22, 52]. However, I argue that repurposing outdated technologies can also gain relevance from nostalgia beyond groups of enthusiasts. This is guided by the findings of previous research, that nostalgia can be effectively utilized for driving consumption [26, 52]. Further indications from literature are the popularity of the AR game *Pokémon Go*, where it was identified that anticipated nostalgia influenced the motivation to play the game in a positive way [60]. As a result, nostalgia has great potential to be utilized as a tool for repurposing. On one hand, people who associate childhood memories with the device may feel a stronger interest and motivation to engage in activities that prolong its lifetime, as observed in the two workshops conducted in the course of this thesis. Additionally, former users who recollect fond memories with the console have considerable knowledge of it. That was clearly evident in the second workshop, as participants viewed the Game Boy from different perspectives, reflecting both the device's special features that allow for repurposing, but also the weaknesses of it. This expertise, which former users have because of their detailed and nostalgic memories, can be exploited to find new uses for the outdated gaming console. As found in literature, expertise is of significant importance in projects for extending objects' lifetime (e.g., [30]).

The user sentiments towards the created artifact further demonstrate how a repurposed device can evoke strong emotional responses, which is found to be an indicator for attachment and, in turn, a beneficial factor for longer product use [41]. Participants described the repurposed Game Boy as familiar, exciting, and fun, with many connecting it to childhood memories and appreciating its retro charm. Some even mentioned that the emotional value it carried could not be replicated by any modern device. However, while nostalgia enhances the emotional appeal, it does not necessarily lead people to overlook practical shortcomings when compared to modern technologies, as observed with the mention of slow response times with the Game Boy smart remote. Nevertheless, the strong emotional connection and retro charm suggest that repurposed technologies can offer unique value that modern devices often lack, while also contributing to resource preservation and waste reduction.

Nostalgia is, however, not only beneficial for reimagining the use of outdated technologies. The shortcomings of nostalgia for repurposing are discussed in the subsequent section.

7.2 Tension: Past and Future of Devices

Previous literature on nostalgia has already highlighted its ambivalence, as it symbolizes a longing for a past that cannot be regained [10]. The yearning to relive or reexperience nostalgic memories exactly as remembered is impossible, yet gaming and virtual environments come close [26, 61]. This raises the question of whether the act of repurposing a relict from the past, which the Game Boy is to many, conflicts with the very concept of nostalgia. The answer to the second research question is intended to clarify this: *How does the tension between preserving nostalgia and the desire to repurpose old technologies, such as the Game Boy, impact users' perceptions and creative envisioning of multiple lives for these devices?*.

In the speculation of giving the Game Boy a new use, different themes emerged that reflect the tension of reimagining an artifact of the past. One particularly striking comment was expressed by a participant during the speculative task, namely *"They're just made for playing, what can you do"*, referring to the purpose of consoles for gaming. This comment is in its notion similar to the statement found in related work, reading as follows: *"A typewriter is always a typewriter while a typewriter"* [32, p. 457]. Whilst in the typewriter example, the claim is that an in-tact state of a device is hindering in thinking of new uses for it, the comment on the gaming console suggests that the Game Boy's original purpose is deeply rooted in participants' minds, making it difficult to imagine new functions beyond its intended use. In reflection on the influence of personal memories on the repurposing idea, one person said that childhood memories were indeed hindering in finding new uses for the device. This was explained by the fact that they had never experienced the device being used for something other than gaming, thus the gaming aspect was difficult to neglect in a new concept. Another response highlighted that the Game Boy is well thought out for the purpose of gaming, so that imagining an alternative use was perceived as difficult. Taken together, these considerations suggest that for some people who maintain a strong recollection of the Game Boy, it is challenging to view it as a blank interaction device open for reinterpretation.

For other people, however, personal memories of the device were not considered as being hindering in finding new uses. In the responses of people who perceived personal memories as not influencing the reimagining or even inspiring, two particpants mentioned specific properties they remembered the device for in their arguments about why they were not negatively influenced by recollections. The buttons and haptic, and the games and the fun factor were essential in their memories of the Game Boy. This suggests that when nostalgic memories are primarily concerned with some facets of the Game Boy's characteristics, it is easier to envision new purposes. In the case of certain elements, as with the buttons and haptic, personal memories were even inspiring. Similarly, two other responses indicate that when nostalgia is associated with a general positive feeling, rather than with concrete gaming experiences, it can be engaging to think about how this feeling can be translated into the present or future by reusing the Game Boy.

While reflections from the second workshop predominantly emphasized the challenges

of preserving nostalgic elements during repurposing, two participants argued that such preservation is not in conflict with repurposing — on the contrary, it can actively support it. From their perspective, the meaning attached to the Game Boy is particularly well-suited for giving it a new purpose. First, its nostalgic appeal can serve as a strong motivational factor, the anticipation that a device evokes positive memories can entice people to use it beyond its original purpose. Second, familiar and emotionally meaningful artifacts can be reassuring when used in unfamiliar or challenging contexts, as their positive associations may help ease discomfort or provide a sense of security.

In summary, the act of repurposing nostalgic artifacts presents a sensitive tension between honoring their emotional value and adapting them for new uses. While some participants were inspired by the creative potential for reuse, other workshop participants and comments posted online express discomfort with modifications that compromised the original form or function, especially when the device was still operational. As highlighted in one comment of a participant regarding the existence of functional examples being a prerequisite for nostalgia, nostalgia was found to be often relying on the integrity and longevity of an object. Altering an object risks erasing the very qualities that make it meaningful, which leads to the conclusion that successful repurposing must strike a careful balance: adding value through reinterpretation for a new use without diminishing the emotional resonance of the original device. Ultimately, any attempt to repurpose a beloved object is likely to leave some feeling that the integrity of it is lost, whether because its "magic" fades when it is no longer used for playing games, or because interacting with it clashes with idealized memories of past gaming experiences.

7.3 Implications

This thesis exemplified the process of repurposing the Game Boy with a central focus on nostalgia. It was highlighted how nostalgic considerations gathered from a workshop with former users of the device and speculations of multiple useful lives shaped the intervention of making the Game Boy suitable for a new use case. Critical comments on other purposing projects with the Game Boy further influenced the implementation of the smart home remote, in that the design was carefully chosen so as not to destroy parts of the console in a way that is not reversible and to keep as much from the original console as possible. The last research question asks about what can be learned from this process, also with regards to implications for other outdated technologies: *"What are the broader implications and lessons learned from the repurposing of the Game Boy for extending the product lifetime of other outdated technologies and how can these findings be applied to inform sustainable interaction design practices in the context of outdated technologies?"*.

To start with, it is important to note that the Game Boy already offers a high degree of *obsolescence resistance*. Many people still hold onto their old Nintendo consoles, even if they do not use them anymore, due to emotional durability that characterizes the Game Boy. Furthermore, postponing the obsolescence is also made accessible, components and

instructions to upgrade the device, such as changing the screen to a lighter one, can be found online to a large extent. Extending the life of the Game Boy by reversing obsolescence also takes place, however, mainly in dedicated communities of fans and enthusiasts. In general, and as demonstrated in this study, it can be said that the Game Boy has a personal and collective significance that is hard to find with other outdated technologies. As a consequence, it is difficult to draw a conclusion about repurposing other outdated technologies from the experience that I have made from working with the Game Boy. For one, because of how profoundly people remember it. The same level of interest and popularity is unlikely to be observed with any other older devices, at least not as universally as with the Game Boy, which resonates across different generations. Secondly, the work at hand benefited a lot from the dedicated communities of modders and enthusiasts. I claim that repurposing other outdated technologies presents more challenges than the Game Boy, especially due to limited resources that support extending their product lifespan. Evidence for this can be found in a related work on e-waste reuse, where it was stated that one of the reasons for stockpiling e-waste was, that people do not know how to reuse obsolete electronics because there are no accessible mechanisms to find creative ideas for new uses [34].

This leads to the lesson learned that the availability of resources is very important for the implementation of reuse projects. My own experience from repurposing an outdated gaming console aligns with literature about the significance of having access to ideas and knowledge shared by other people. Personally, I would not have been able to realize this project of turning a Game Boy into a smart home remote in a way that maintains all the original hardware and software if it was not for the instructions and tools made available online by fans and enthusiasts of retro consoles. There is a variety of assistance online, ranging from tools to convert bitmaps to C files to dedicated hardware and a support Discord channel for flashing custom cartridges, that helps to get started and lower some of the barriers in the process.

With regard to the broader implications of this process for other outdated technologies, I propose that greater attention should be given to add-ons in product life extension aims. Both in the speculative design workshop and in the negative comments on repurposed Game Boys it was apparent that destroying parts of the original hardware or the console's purpose for gaming is difficult for some people to accept as it compromises the value they associate with it. Add-ons, on the other hand, as exemplified in the prototype created in the course of this thesis, have the advantage that they retain the original value completely or to a high degree while extending it through new functions. Provided that such inventions are easily removable, it can be assumed that reversible solutions for reimagining the use of outdated technologies are more likely to be accepted by a broader audience, including people who are particularly appreciative of the original form or the intended gaming use. This finding can inform Sustainable Interaction Design, as introduced by Eli Blevis [8], by adding *augmenting without altering* as a preferable strategy within the rubric for assessing the material effects of design choices - potentially ranking higher than remanufacturing for reuse in terms of environmental impact.

Lastly, the case study of repurposing the Game Boy highlights the positive effects of using nostalgia as a central theme to engage users in considerations of product life extension. The study exemplifies a design approach that actively involves users and potentially creates engagement beyond the scope of the workshops. By creatively reimagining an outdated technology that participants can relate to, the project draws attention to the value of resourcefulness - using existing technologies to meet present or future needs. Such past-oriented concepts show how nostalgic appeal can not only foster attachment, but also support more sustainable behaviors and values. Other outdated technologies can be used in the same way to promote engagement and sustainable thinking in workshops and beyond.

7.4 Contributions

This thesis adds to the existing body of research regarding nostalgia and extending product life in three ways, namely through empirical, artifact and methodological contributions [59].

With the aim of closing the research gap of intentionally utilizing nostalgia to prolong the lives of outdated technologies, the qualitative data that was collected in the two workshops with participants reveal how nostalgia and personal memories can engage former users of outdated gaming consoles to imagine new uses for them and as a consequence promote longer use. With the focus on the tension of preserving nostalgia in reuse aspirations, the empirical data further unveils how emotional attachment to technologies can hinder efforts to alter or repurpose them. The limitations in generalizing these findings to other outdated technologies, as described above, stem from the unique personal and collective memories people associate with the Game Boy.

The tangible prototype created in the course of this research represents an artifact contribution. It is the result of a speculation about how untapped resources stored away in drawers or attics, such as the Game Boy, can be utilized for new purposes instead of buying new products. The prototype demonstrates how outdated devices can be reimagined and thus promote a more sustainable approach to technology consumption which better exploits resources. With this design aim, the artifact invites to consider alternative futures for technologies at the point of perceived obsolescence.

The methodological contribution consists of the finding that the design of *add-ons* and its accompanying strategy *augmenting without altering* should be considered in Sustainable Interaction Design. Adding value while retaining the original value can be regarded as a favorable approach to engaging with outdated technologies that hold nostalgic significance and can inform current practices of promoting renewal and reuse.

7.5 Limitations

The objective of the thesis was to promote reuse of outdated technologies by demonstrating how the Game Boy can be repurposed to motivate a more sustainable approach to technology consumption. A limitation that arises from this research objective is that the study does not account for how sustainable the newly created add-on to the Game Boy is, other than it potentially resulting in a longer use of the Game Boy and avoiding the purchase of a dedicated smart home remote. However, new resources were needed to create the artifact, including several 3d printed cases that were discarded in the process of making it fit the technical components and adapting it to slide smoothly onto the Game Boy console.

Another limitation of the work in regards to the prototype lies in the speculative artifact not being shared with a broader audience. One common critique about speculative design is its *elitism* - that the results are often contained in the realm of museum exhibitions. Although the prototype was shared with people outside of an exhibition context, it was nevertheless in an academic setting where participants were asked to interact with it. Contrary to the aim of speculative design to shift discussions about technology beyond experts to a wider audience, only five people contributed to the reflection on the meaningfulness of the intervention to promote multiple lives and, thus, longer use.

Finally, the recruitment exclusively from my personal circle of friends for the participatory methods used in this study might have contributed to the responses being sympathetic to the research aim. An indication of this influence can be found in the statements and reflections from the participants in the speculative design workshop, as reflected in 4.4.4. Further, the fact that environmental concerns were considered a strong influence in the speculative task among all participants, which is contrary to observations in related works, might be a reflection of their position within my own social circle, which shares similar values and backgrounds.

7.6 Future Work

Resulting from the limitation of the work at hand, future research should aim to assess the extent to which reuse has an actual positive environmental impact. To be more precise, how the longer use resulting from repurposing contributes to reducing waste, taking into account the resources required to develop the new uses. A special focus could be placed on add-ons and the extent to which this type of intervention is preferable to other methods with regard to the environment.

To substantiate the finding that nostalgia can be effective in reimagining outdated technologies, future studies should explore this topic with a focus on other obsolete technologies. Examining the repurposing potential for other outdated technologies on the basis of nostalgia can reveal whether the Game Boy's broad popularity and nostalgic appeal is as significant for the envisioning of new uses as concluded from the study at hand.

Regarding the prototype, two alternative implementations could be explored in future work. Firstly, repurposing the Game Boy in a way that destroys parts of the hardware and/or its original use for gaming. Testing such an intervention with former users of the device can clarify whether the emotionally charged comments found online associated with "destroyed" Game Boys are limited to dedicated groups of enthusiasts or if such drastic changes are universally poorly accepted among people with different levels of connection to the device. Secondly, repurposing the Game Boy for other uses could be examined in future research with the aim of finding out if other uses, including non practical ones, are also considered meaningful augmentations.

CHAPTER 8

Conclusion

This thesis explored nostalgia as a means to promote reuse and repurposing using the example of the Game Boy. With nostalgia as a guiding principle in lifespan extension efforts, a new approach was studied that draws on the emotional attachment and detailed knowledge former users have of outdated technologies. This proposed idea is in response to short-lived relationships with products and fast throughput of resources. By adapting a product for use beyond its original purpose, new value can be created in something otherwise considered obsolete - unlocking its potential rather than leaving it unused or discarding it. In this way, not only waste can be avoided, but resources, human effort and knowledge that went into the manufacturing of the original product are also exploited better.

In the case of the Game Boy, nostalgia has proven to be useful for repurposing. However, not without limitations. Throughout the study, it was apparent that people care about the console, as participants of the workshops described in detail their recollections of the device and the memories it achieved to evoke more than 20 years after it was released. With that, it was found that former users have a lot of knowledge about the device, both in terms of properties that made it special and recognizable and shortcomings it has compared to modern technologies. The expertise former users have due to their experience with the device can be leveraged to explore alternative uses. Their prior familiarity and personal connection to the device can serve as motivating factors, sparking interest to engage in activities to extend its useful life. In the participatory design activities, participants reflected on how the positive emotions evoked by the Game Boy could inspire new functionalities suited to present or future needs. Prompted by the speculative scenario of reusing untapped resources people already owned but not used, participants looked beyond nostalgia to explore the Game Boy's potential as an interactive device, detached from its original gaming context. While this perspective of giving the device a second useful life and its personal significance were inspiring for some, other participants shared the opinion that fond recollections and the aim to preserve the nostalgic appeal

of the Game Boy were hindering in envisioning new uses. For them, associated memories were perceived as restrictive when thinking of uses beyond the gaming purpose it was designed for, as the *magic* of the Game Boy would be lost if it was no longer used for gaming. Designing a new functionality was considered a challenge, because it could potentially undermine the (idealized) memories tied to the original experience.

This study demonstrated how nostalgia can be successfully leveraged in the design of a repurposed Game Boy, as shown by the positive reception of the created artifact, which was perceived as a meaningful augmentation of the original console. Drawing on the findings about the positive implications of nostalgic appeal and accompanied conflicts of preserving essential elements, a Game Boy Advance SP was repurposed as a smart home remote. To respect the sentimental value many users attach to certain properties and the use as a gaming console, the prototype was developed in a way, that maintains all parts of the device while adding the functionality of controlling lights. The work suggests that "add-ons" to outdated technologies offer a promising strategy for product life extension endeavors, as they are more likely to be approved by a broader audience, including people who are particularly keen on keeping the legacy of retro technologies alive.

APPENDIX A

Friendship Book

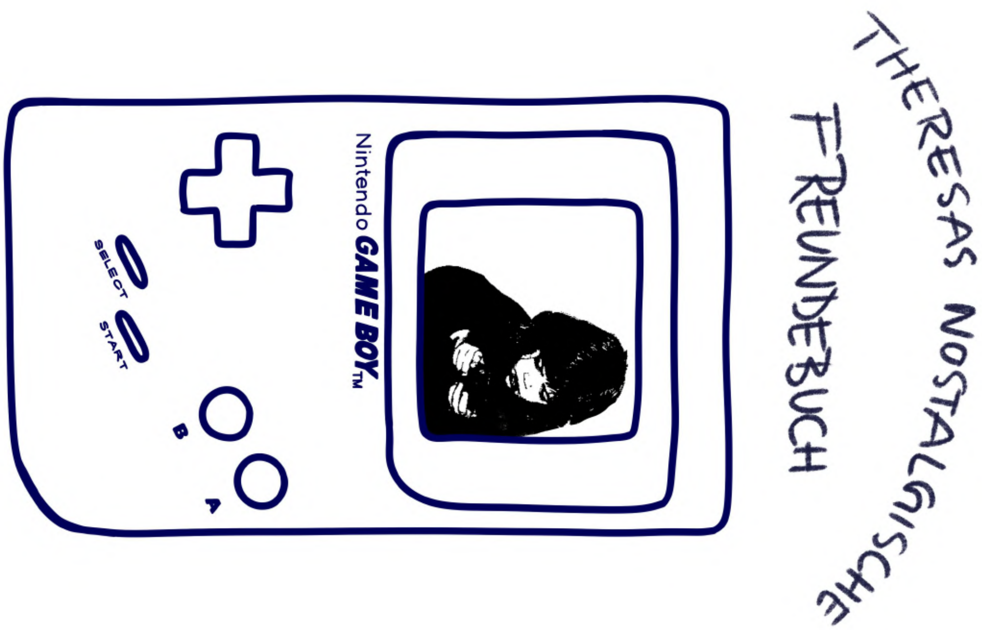

Figure A.1: Title page

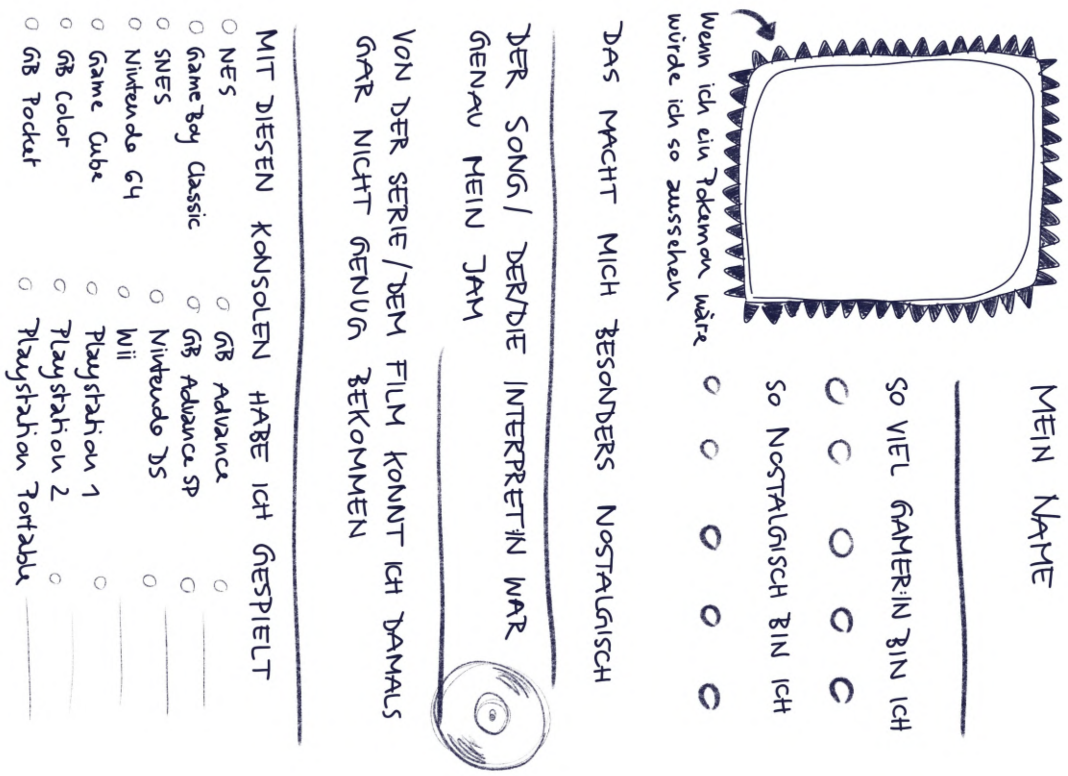

Figure A.2: First page

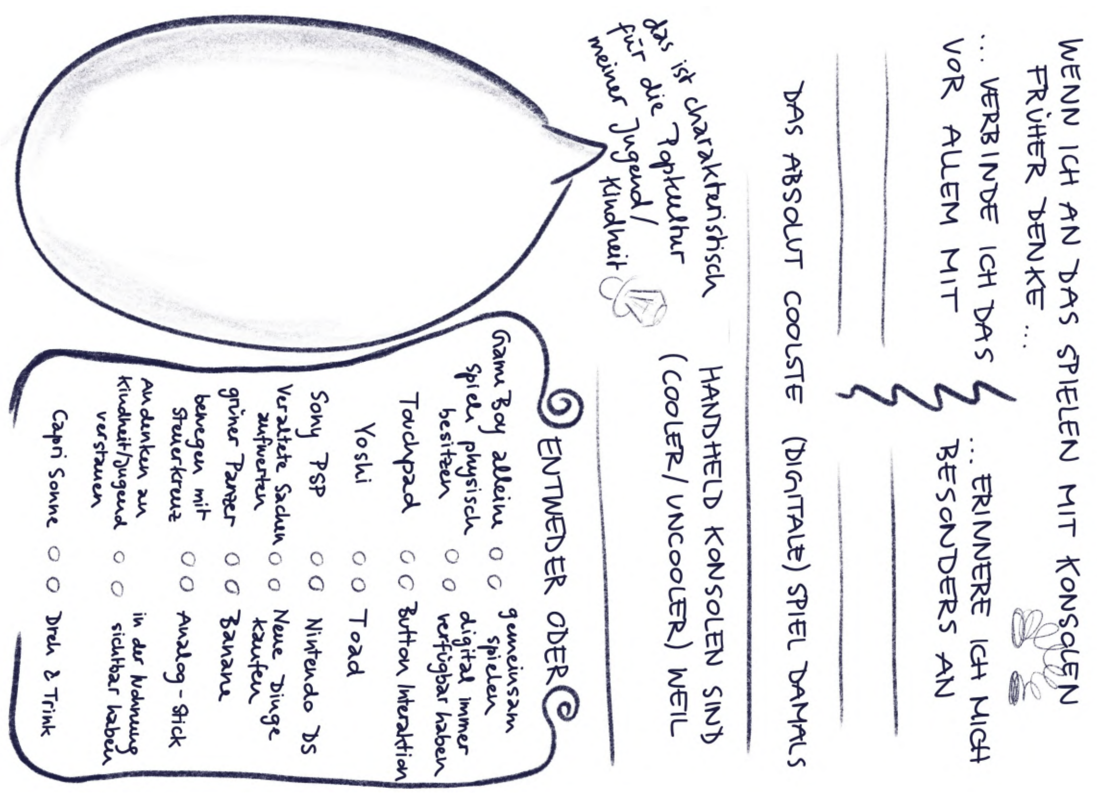

Figure A.3: Second page

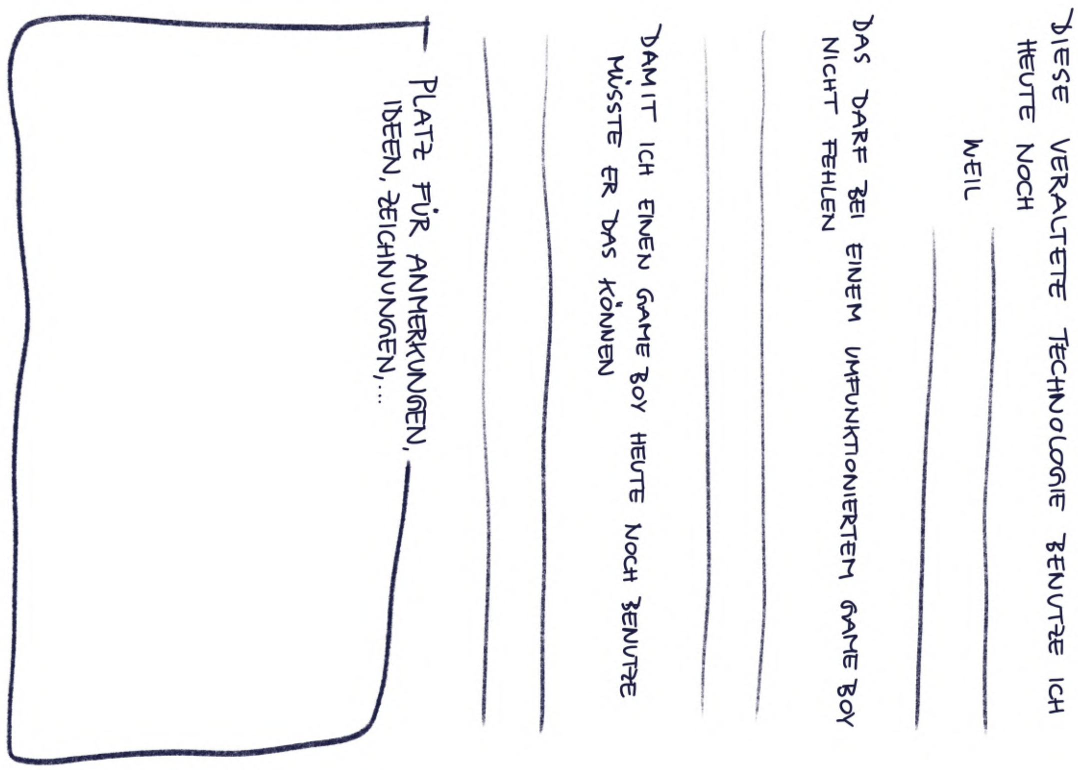

Figure A.4: Last page

APPENDIX B

Reflection Questionnaire

Workshop Reflexion

Hello!

Hier sind 4 knackige Fragen, die dich bisschen dazu anregen sollen den Workshop zu reflektieren und mir gleichzeitig super helfen werden meine Forschungsfragen zu beantworten :)
Danke danke danke fürs Mitmachen 💫

Zur Info: Bei einigen Fragen steht "Game Boy" - das ist stellvertretend für handheld Nintendo Konsolen der 90er bis 2000er zu verstehen (also eh so wie im Workshop, dh. Game Boy Classic bis Advance SP)

* Gibt eine erforderliche Frage an

1. Dein Name (*damit ich Konzept/Idee zu den Antworten matchen kann*) *

2. Welche Elemente des Game Boys hast du in deiner Idee beibehalten, und aus welchem Grund? *

3. Wie sehr haben die folgenden Themen deine Designentscheidungen beeinflusst? *
(1 = Gar nicht, 2 = Wenig, 3 = Neutral, 4 = Stark, 5 = Sehr stark)

Markieren Sie nur ein Oval pro Zeile.

	1	2	3	4	5
Persönliche Erinnerungen an den Game Boy	◯	◯	◯	◯	◯
Die kulturelle und symbolische Bedeutung des Game Boys	◯	◯	◯	◯	◯
Die Funktionalität und ursprüngliche Nutzung des Game Boys	◯	◯	◯	◯	◯
Die ästhetischen Elemente des Game Boys	◯	◯	◯	◯	◯
Die Berücksichtigung von Nachhaltigkeit	◯	◯	◯	◯	◯
Der Erhalt von Materialien und Ressourcen	◯	◯	◯	◯	◯
Die Reduktion von Abfall und Elektroschrott	◯	◯	◯	◯	◯
Die Anpassung an zukünftige Bedürfnisse und Kontexte	◯	◯	◯	◯	◯

4. Wie hast du den Spagat zwischen der Nostalgie des Game Boys und der Notwendigkeit, ihn für einen anderen Zweck neu zu denken, wahrgenommen? Wie hat dieser Balanceakt deinen kreativen Prozess beeinflusst? *

5. Wie haben deine persönlichen Erfahrungen mit dem Game Boy deine Idee geprägt? Waren sie eher inspirierend oder hast du sie als Einschränkungen empfunden, eine neue Verwendung zu finden? *

6. Raum für sonstige Anmerkungen

APPENDIX C

Code

C.1 Microcontroller

The following code was written in MicroPython using the uPyCraft IDE.

```
from machine import Pin, ADC
import time
import network
import urequests
from displayHandler import displayRowsOfText, resetDisplay

# Sensors, Buttons
ldr = ADC(Pin(36))
ldr.atten(ADC.ATTN_11DB)

potentiometer = ADC(Pin(34))
potentiometer.atten(ADC.ATTN_11DB)

button = Pin(2, Pin.IN, Pin.PULL_UP)

# 1 == off, 0 == pressed
button_lastState = 1
button_currentState = None

pause_time = 0.5

#Signal thresholds
threshold = 4000
tolerence = 7
max_pattern_count = 180
min_pulses_length = 20
max_pulses_entries = 4
```

```
28
29 #pattern recognition
30 pulses = []
31 current_state = None
32 pattern_started = False
33 on_count = 0
34 off_count = 0
35
36 pattern_to_classify = None
37 action_to_execute = None
38
39 # Timing patterns from GBA
40 patterns = {
41     "signal1": [30, 60, 30, 60],
42     "signal2": [60, 30, 60, 30],
43     "signal3": [45, 45, 45, 45],
44     "signal4": [30, 30, 60, 60],
45     "signal5": [60, 60, 30, 30],
46 }
47
48 # Wifi credentials
49 ssid = 'wifi123'
50 password = 'securePassword456'
51 wlan = network.WLAN(network.WLAN.IF_STA)
52 wlan.active(True)
53
54 debugInformation = [""] * 5
55 prev_debugInformation = debugInformation.copy()
56
57 # 0 == Wifi, 1 == Calibrate, 2 == Pattern Recognition
58 programState = 0
59
60 # Home Assistant API Details
61 HOME_ASSISTANT_IP = "homeassistant"
62 ACCESS_TOKEN = "xxxx"
63 ENTITY_ID_1 = "light.smart_rgbtw_bulb"
64 ENTITY_ID_2 = "light.smart_rgbtw_bulb_2"
65 ENTITY_ID_3 = "light.smart_rgbtw_bulb_3"
66
67 # light properties
68 brightness_levels = [0, 28, 56, 85, 113, 141, 170, 198, 226, 255]
69 colors = [
70     [255, 0, 0],       # Red
71     [0, 255, 0],       # Green
72     [0, 0, 255],       # Blue
73     [255, 255, 0],     # Yellow
74     [255, 0, 255],     # Magenta
75     [0, 255, 255],     # Cyan
76     [255, 165, 0],     # Orange
```

```
77      [128, 0, 128],     # Purple
78      [255, 190, 120],   # Warm White
79      [200, 200, 255]    # Cold White
80  ]
81  brightness_index = 0
82  colors_index = 0
83
84  def init():
85    resetDisplay()
86    resetPatternParams()
87    doConnect()
88
89    displayRowsOfText(debugInformation)
90
91  def checkButtonPress():
92    global programState
93    global debugInformation
94    global pause_time
95    global button_lastState
96    global button_currentState
97
98    button_currentState = button.value()
99    if button_currentState == 0 and button_lastState == 1:
100     programState = (programState + 1) % 3
101     for i in range(len(debugInformation)):
102       debugInformation[i] = ""
103     resetDisplay()
104     resetPatternParams()
105     pause_time = 0.5
106
107   button_lastState = button_currentState
108
109 def updateDisplayIfNeeded():
110   if prev_debugInformation != debugInformation:
111     displayRowsOfText(debugInformation)
112
113 def doConnect():
114   global debugInformation
115
116   if not wlan.isconnected():
117     debugInformation[1] = "connecting..."
118     wlan.connect(ssid, password)
119
120     timeout = 10
121     start = time.time()
122     while not wlan.isconnected():
123       if time.time() - start > timeout:
124         debugInformation[1] = "Connection␣failed"
125         return
```

```
126         time.sleep(1)
127
128     else:
129       debugInformation[1] = "connected:"
130       debugInformation[2] = "{}".format(wlan.ifconfig()[0])
131
132 def calibrate_threshold():
133     global debugInformation
134     global threshold
135     threshold = potentiometer.read()
136     debugInformation[1] = "Threshold: {}".format(potentiometer.read())
137     lightValue = ldr.read()
138     if lightValue > threshold:
139       debugInformation[2] = "ON: {}".format(lightValue)
140     else:
141       debugInformation[2] = "OFF: {}".format(lightValue)
142
143 def detectPattern():
144     global pulses
145     global current_state
146     global pattern_started
147     global on_count
148     global off_count
149     global pattern_to_classify
150
151     global pause_time
152     pause_time = 0.02
153
154     ldr_value = ldr.read()
155     light_on = ldr_value > threshold
156     if light_on:
157       print("ON")
158     else:
159       print(ldr_value)
160
161     current_time = time.time()
162
163     # transition: start pattern (first on phase)
164     if light_on and not pattern_started:
165       pattern_started = True
166       current_state = "ON"
167
168     # count: first on phase
169     elif light_on and pattern_started and current_state == "ON":
170       on_count += 1
171
172     # transition: first OFF phase
173     elif not light_on and pattern_started and current_state != "OFF":
174       pulses.append(on_count)
```

```
175       on_count = 0
176       current_state = "OFF"
177
178     # count: first off phase
179     elif not light_on and pattern_started and current_state == "OFF":
180       off_count += 1
181       if len(pulses) > 2 and (((sum(pulses) + off_count) >
           max_pattern_count) or off_count > 60):
182         pulses.append(off_count)
183
184     # transition: second on phase
185     elif light_on and current_state != "ON":
186       pulses.append(off_count)
187       off_count = 0
188       current_state = "ON"
189
190     debugInformation[2] = "{}".format(pulses)
191
192     # end condition
193     if sum(pulses) > max_pattern_count or len(pulses) >=
           max_pulses_entries:
194       pattern_to_classify = pulses
195       pause_time = 0.5
196
197 def resetPatternParams():
198     global pulses
199     global current_state
200     global pattern_started
201     global on_count
202     global off_count
203     global pattern_to_classify
204     global action_to_execute
205
206     pulses = []
207     current_state = None
208     pattern_started = False
209     on_count = 0
210     off_count = 0
211
212     pattern_to_classify = None
213     action_to_execute = None
214
215     debugInformation[3] = ""
216
217 def classifyPattern(pulses):
218     global pattern_to_classify
219     global action_to_execute
220
221     debugInformation[3] = "classifying..."
```

```
222
223   for color, reference in patterns.items():
224     if len(pulses) == len(reference):
225       match = all(abs(m - r) <= tolerence for m, r in
      zip(pulses[:-1], reference[:-1]))
226       if match:
227         print("MATCH:")
228         print(color)
229         pattern_to_classify = None
230         action_to_execute = color
231         return
232       else:
233         resetPatternParams()
234     else:
235       resetPatternParams()
236
237 # Send HTTP request to Home Assistant
238 def control_light(state, entity_id, brightness=None, rgb_color=None):
239   url = f"http://{HOME_ASSISTANT_IP}:8123/api/services/light/{state}"
240   headers = {
241     "Authorization": f"Bearer␣{ACCESS_TOKEN}",
242     "Content-Type": "application/json"
243   }
244   data = {"entity_id": entity_id}
245
246   if brightness is not None:
247     data["brightness"] = brightness
248
249   if rgb_color is not None:
250     data["rgb_color"] = rgb_color
251
252   print("Sending␣request:", data)
253
254   try:
255     response = urequests.post(url, json=data, headers=headers)
256     print("Response:", response.text)
257     response.close()
258   except Exception as e:
259     print("Request␣failed:", e)
260
261 def movieScene():
262   control_light("turn_on", ENTITY_ID_1, brightness= 84,
      rgb_color=[74, 107, 255])
263   control_light("turn_on", ENTITY_ID_2, brightness= 0, rgb_color=[0,
      0, 255])
264   control_light("turn_on", ENTITY_ID_3, brightness= 30,
      rgb_color=[185, 87, 255])
265
266 def readingScene():
```

```
267   control_light("turn_on", ENTITY_ID_1, brightness= 92,
        rgb_color=[255, 196, 147])
268   control_light("turn_on", ENTITY_ID_2, brightness= 200,
        rgb_color=[255, 196, 147])
269   control_light("turn_on", ENTITY_ID_3, brightness= 92,
        rgb_color=[255, 196, 147])
270
271 def partyScene():
272   control_light("turn_on", ENTITY_ID_1, brightness= 160,
        rgb_color=[255, 0, 205])
273   control_light("turn_on", ENTITY_ID_2, brightness= 173,
        rgb_color=[255, 0, 36])
274   control_light("turn_on", ENTITY_ID_3, brightness= 80,
        rgb_color=[0, 147, 255])
275
276 def executeAction(pattern):
277   global debugInformation
278   global brightness_index
279   global colors_index
280
281   print("EXEC:")
282   print(pattern)
283   temp = ""
284   if pattern == "signal1":
285     temp = "exec␣signal1"
286     movieScene()
287   elif pattern == "signal2":
288     temp = "exec␣signal2"
289   elif pattern == "signal3":
290     temp = "exec␣signal3"
291   elif pattern == "signal4":
292     temp = "exec␣signal4"
293     readingScene()
294   elif pattern == "signal5":
295     temp = "exec␣signal5"
296     partyScene()
297   else:
298     temp = "Unknown"
299   debugInformation[3] = temp
300   resetPatternParams()
301
302
303 def main():
304   global debugInformation
305   global prev_debugInformation
306   init()
307
308   # Main Loop
309   while True:
```

```
310
311     checkButtonPress()
312
313     if programState == 0:
314       debugInformation[0] = "WIFI"
315
316       doConnect()
317
318     elif programState == 1:
319       debugInformation[0] = "CALIBRATE"
320       calibrate_threshold()
321
322     elif programState == 2:
323       debugInformation[0] = "PATTERN"
324       if pattern_to_classify:
325         classifyPattern(pattern_to_classify)
326       elif action_to_execute:
327         executeAction(action_to_execute)
328       else:
329         detectPattern()
330
331     updateDisplayIfNeeded()
332     prev_debugInformation = debugInformation.copy()
333
334
335     time.sleep(pause_time)
336
337
338 main()
```

C.2 Game Boy Advance ROM

The following code was written in C and compiled using `make` inside an MSYS2 environment, producing a `.gba` file

```c
/*
    Adapted from GBA_MODE_5_Starter project by 3DSage (https://github.com/3DSage/GBA_Mode_5_Starter) under MIT License.

    Modifications made for project-specific functionality
*/

//---#defines---
#include "gba.h"
#include <stdbool.h>
//---Math functions---
#include <math.h>
//---Load textures---
#include "textures/titleScreen.c"
#include "textures/movie_off.c"
#include "textures/movie_on.c"
#include "textures/book_off.c"
#include "textures/book_on.c"
#include "textures/party_off.c"
#include "textures/party_on.c"



//---Global variables---
#define     GBA_SW 160                                          // actual gba screen width
#define     GBA_SH 128                                          // actual gba screen width
#define     SW     120                                          // game screen width
#define     SH      80                                          // game screen height
#define     RGB(r,g,b) ((r)+((g)<<5)+((b)<<10))                 // 15 bit, 0-31, 5bit=r, 5bit=g, 5bit=b
#define     WHITE RGB(31, 31, 31)
#define     BLACK RGB(0, 0, 0)
#define     SIGNAL_DURATION 60                                  // number of frames the signal is should be drawn
```

```
32
33  int signalTimer = 0;                                    // timer for signal duration
34  int lastFr = 0, FPS = 0;                                // for frames per second
35  int gameState = 0;                                      // game state, title, game, ending
36  int endScreenTimer = 0;                                 // time in second to hold on the
        ending
37
38  int hovered_index = 0;
39  int selected_index = -1;
40
41  // signal box dimensions
42  int signal_x = 106, signal_y = 2, signal_w = 12, signal_h = 12;
43
44
45  void clearBackground()
46  {
47      int x, y;
48      for (x = 0; x < SW; x++)
49      {                                                                   //rgb values 0-31
50          for (y = 0; y < SH; y++) { VRAM[y * GBA_SW + x] = BLACK; }      //clear all 120x80 pixels
51      }
52  }
53
54
55  IN_IWRAM void drawImage(int w, int h, int xo, int yo, const u16* map, int to)   //image w/h,
        position offset,  texture name, texture offset
56  {
57      int x, y, c;
58      for (x = 0; x < w; x++)
59      {
60          for (y = 0; y < h; y++) { c = map[(y + to * h) * w + x]; if (c > 0) { VRAM[(y + yo) *
        GBA_SW + x + xo] = c; } }
61      }
62  }
```

```
IN_IWRAM void drawModeImage(int w, int h, int xo, int yo, const u16* map, int to, int hovered)
    //image w/h, position offset,  texture name, texture offset, is hovered
{
    int x, y, c;
    for (x = 0; x < w; x++)
    {
        for (y = 0; y < h; y++)
        {
            c = map[(y + to * h) * w + x];
            if (c > 0)
            {
                VRAM[(y + yo) * GBA_SW + x + xo] = c;
            }
        }
    }

    // draw border if selected
    if (hovered)
    {
        // top and bottom border
        for (x = -1; x <= w; x++)
        {
            int tx = xo + x;
            if (tx < 0 || tx >= GBA_SW) continue;

            if (yo - 1 >= 0) VRAM[(yo - 1) * GBA_SW + tx] = WHITE;
            if (yo + h < GBA_SH) VRAM[(yo + h) * GBA_SW + tx] = WHITE;
        }

        // left and right border
        for (y = -1; y <= h; y++)
        {
            int ty = yo + y;
```

```
            if (ty < 0 || ty >= GBA_SH) continue;

            if (xo - 1 >= 0) VRAM[ty * GBA_SW + (xo - 1)] = WHITE;
            if (xo + w < GBA_SW) VRAM[ty * GBA_SW + (xo + w)] = WHITE;
        }
    }
}


void drawRectangle(int x, int y, int w, int h, uint16_t color)
{
    int xi, yi;
    for (xi = 0; xi < w; xi++)
    {
        for (yi = 0; yi < h; yi++) { VRAM[(y+yi) * GBA_SW + (x+xi)] = color; }
    }
}

typedef struct {
    int x, y, width, height;
    const u16* map_on;          // map for selected state
    const u16* map_off;         // map for not selected state
}Mode;

Mode modes[3] = {
    {5, 25, 32, 32, movie_on_Map, movie_off_Map},
    {44, 25, 32, 32, book_on_Map, book_off_Map},
    {83, 25, 32, 32, party_on_Map, party_off_Map}
};

// unique timing patterns (short/long pulses)
int patternTimings[5][4] = {
    {10, 20, 10, 20}, // mode 1 (movie) -> 10 frames white, 20 black, 10 white, 20 black
    {10, 10, 20, 20}, // mode 2 (reading)
```

```
    {20, 20, 10, 10}, // mode 3 (party)
    {20, 10, 20, 10}, // extra signal
    {15, 15, 15, 15}, // extra signal
};

void drawMode(int modeIndex)
{
    Mode mode = modes[modeIndex];
    const u16* colormap;

    bool isSelected = (modeIndex == selected_index);
    bool isHovered = (modeIndex == hovered_index);

    if (isSelected) {
        colormap = mode.map_on;
    }
    else {
        colormap = mode.map_off;
    }

    drawModeImage(mode.width, mode.height, mode.x, mode.y, colormap, 0, isHovered);
}

void drawSignal() {
    int frameCount = SIGNAL_DURATION - signalTimer;
    int* timing = patternTimings[selected_index];

    if (frameCount < timing[0]) {
        drawRectangle(signal_x, signal_y, signal_w, signal_h, WHITE);
    }
    else if (frameCount < (timing[0] + timing[1])) {
        drawRectangle(signal_x, signal_y, signal_w, signal_h, BLACK);
    }
    else if (frameCount < (timing[0] + timing[1] + timing[2])) {
```

```
164         drawRectangle(signal_x, signal_y, signal_w, signal_h, WHITE);
165     }
166     else {
167         drawRectangle(signal_x, signal_y, signal_w, signal_h, BLACK);
168     }
169 }
170 
171 //---MUSIC-------------------------------------------------------------------
172 typedef struct
173 {
174     u16* song;
175     int tic;
176     int spd;
177     int size;
178     int onOff;
179     int loop;
180 }Music; Music M[5];
181 
182 u16 notes[] =
183 {
184    44, 157,  263, 363,  458,  547, 631,  711, 786,  856, 923,  986, //C2,C2#, D2,D2#, E2, F2,F2#,
       G2,G2#, A2,A2#, B2
185  1046,1102, 1155,1205, 1253, 1297,1340, 1379,1417, 1452,1486, 1517, //C3,C3#, D3,D3#, E3, F3,F3#,
       G3,G3#, A3,A3#, B3
186  1547,1575, 1602,1627, 1650, 1673,1694, 1714,1732, 1750,1767, 1783, //C4,C4#, D4,D4#, E4, F4,F4#,
       G4,G4#, A4,A4#, B4
187  1798,1812, 1825,1837, 1849, 1860,1871, 1881,1890, 1899,1907, 1915, //C5,C5#, D5,D5#, E5, F5,F5#,
       G5,G5#, A5,A5#, B5
188  1923,1930, 1936,1943, 1949, 1954,1959, 1964,1969, 1974,1978, 1982, //C6,C6#, D6,D6#, E6, F6,F6#,
       G6,G6#, A6,A6#, B6
189  1985,1989, 1992,1995, 1998, 2001,2004, 2006,2009, 2011,2013 ,2015, //C7,C7#, D7,D7#, E7, F7,F7#,
       G7,G7#, A7,A7#, B7
190 };
191 
```

```
u16 song_1[] = { 24, 0, 28, 0, 31, 33, 0, 36, 31, 28, 0, 24, 0, 19, 0, 22 };
u16 song_2[] = { 24, 28, 24, 29, 24, 28, 24, 31, 24, 28, 32, 28, 36, 28, 31, 24 };
u16 song_3[] = { 20, 0, 23, 0, 27, 0, 30, 0, 32, 0, 27, 0, 24, 0, 20, 0 };
u16 sound_1[] = { 36, 39, 43, 46, 48 };
u16 sound_2[] = { 32, 34, 36, 39, 44 };

void playSong(int s)
{
    if (FPS % M[s].spd == 0 && M[s].onOff == 1)
    {
        int note = M[s].song[M[s].tic];
        if (note > 0) {
            PlayNote(notes[note], 64);
        }
        M[s].tic += 1;
        if (M[s].tic > M[s].size) {
            M[s].tic = 0;
            if (M[s].loop == 0) {
                M[s].onOff = 0;
            }
        }
    }
}

void playSongs() {
    for (int i = 0; i < 5; i++) {
        playSong(i);
    }
}

//-----------------------------------------------------------------------------

void buttons()
{
```

```
226     if (KEY_R) { if (hovered_index < 2) { hovered_index += 1; } }  // hovered index + 1
227     if (KEY_L) { if (hovered_index > 0) { hovered_index -= 1; } }  // hovered index - 1
228     if (KEY_A && signalTimer < 1) { selected_index = hovered_index; signalTimer =
        SIGNAL_DURATION; M[4].onOff = 1; }    // set selected index = hovered index, send signal
229 }
230
231 void init()
232 {
233     endScreenTimer = 0;                                                    //clear timer
234     //init music
235     M[0].song = song_1; M[0].spd = 3; M[0].tic = 0; M[0].size = 15; M[0].onOff = 1; M[0].loop = 1;
236     M[1].song = song_2; M[1].spd = 2; M[1].tic = 0; M[1].size = 15; M[1].onOff = 0; M[1].loop = 1;
237     M[2].song = song_3; M[2].spd = 2; M[2].tic = 0; M[2].size = 15; M[2].onOff = 0; M[2].loop = 1;
238     M[3].song = sound_1; M[3].spd = 2; M[3].tic = 0; M[3].size = 5; M[3].onOff = 0; M[3].loop = 0;
239     M[4].song = sound_2; M[4].spd = 2; M[4].tic = 0; M[4].size = 5; M[4].onOff = 0; M[4].loop = 0;
240 }
241
242 int main()
243 {
244     int x, y;
245     //Init mode 5-----------------------------------------------------------------
246     *(u16*)0x4000000 = 0x405;                                              // mode 5 background 2
247     *(u16*)0x400010A = 0x82;                                               // enable timer for fps
248     *(u16*)0x400010E = 0x84;                                               // cnt timer overflow
249
250     //scale small mode 5 screen to full screen-----------------------------------
251     REG_BG2PA = 256 / 2;                                                   // 256=normal 128=scale
252     REG_BG2PD = 256 / 2;                                                   // 256=normal 128=scale
253
254     init();
255
256     while (1)
257     {
258         if (REG_TM2D >> 12 != lastFr)                                      // draw 15 frames a second
```

```
        {
            if (gameState == 0)          // title screen: calibrate threshold ----------------
            {
                drawImage(120, 80, 0, 0, titleScreen_Map, 0);
                playSongs();
                if (KEY_ST) {
                    gameState = 1;
                    M[0].onOff = 0;
                }
                else if (KEY_RS || KEY_LS) { drawRectangle(signal_x, signal_y, signal_w, signal_h, WHITE); }
                else {
                    drawRectangle(signal_x, signal_y, signal_w, signal_h, BLACK);
                }
            }

            else if (gameState == 1)     // main screen: modes + signals ----------------
            {
                buttons();
                clearBackground();
                playSongs();

                for (int i = 0; i < 3; i++) {
                    drawMode(i);
                }

                if (signalTimer > 0) {                            // display the signal only while the timer is running
                    drawSignal(signalTimer);
                    signalTimer--;                                // decrease the timer each frame
                }
            }

```

```
            //frames per second------------------------------------------------------------
            //VRAM[15]=0; VRAM[FPS]=RGB(31,31,0);                   // draw fps
            FPS += 1; if (lastFr > REG_TM2D >> 12) { FPS = 0; }     // increase frame
            lastFr = REG_TM2D >> 12;                                // reset counter

            //swap buffers-----------------------------------------------------------------
            while (*Scanline < 160) {}                                          // wait all
    scanlines
            if (DISPCNT & BACKB) { DISPCNT &= ~BACKB; VRAM = (u16*)VRAM_B; }    // back  buffer
            else { DISPCNT |= BACKB; VRAM = (u16*)VRAM_F; }                     // front buffer
        }
    }
}
```

Overview of Generative AI Tools Used

For this thesis, the following AI tools were used:

1. **DeepL** [1]
   - Version: Free Version
   - Usage: For translation purposes from the native language (German) into the language of the thesis
   - Place of use: Whole thesis
2. **Grammarly** [2]
   - Version: Pro Version, 7 day free trial
   - Usage: To check for correct spelling and grammar
   - Place of use: Whole thesis
3. **ChatGPT** [3]
   - Version: 4o, free Version
   - Usage: For paraphrasing purposes and ideation of workshop contents
   - Place of use: Whole thesis

The generated text primarily served as an inspiration. The suggestions were reviewed and rephrased using own words.

[1] https://www.deepl.com/
[2] https://www.grammarly.com
[3] https://chatgpt.com

Übersicht verwendeter Hilfsmittel

Für diese Arbeit wurden folgende KI Hilfsmittel verwendet:

1. **DeepL** [4]
   - Version: Gratis Version
   - Verwendung: Für Übersetzungszwecke von der Muttersprache (Deutsch) in die Sprache der Arbeit
   - Ort der Verwendung: Ganze Arbeit
2. **Grammarly** [5]
   - Version: Pro Version, 7 Tage kostenlose Testversion
   - Verwendung: Überprüfung auf korrekte Rechtschreibung und Grammatik
   - Ort der Verwendung: Ganze Arbeit
3. **ChatGPT** [6]
   - Version: 4o, gratis Version
   - Verwendung: Für Paraphrasierungszwecke und der Ideenfindung von Workshop Inhalten
   - Ort der Verwendung: Ganze Arbeit

Der generierte Text diente vorrangig der Inspiration. Die Vorschläge wurden überprüft und in eigenen Worten wiedergegeben.

[4] https://www.deepl.com/
[5] https://www.grammarly.com
[6] https://chatgpt.com

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Bibliography

[1] Earth overshoot day. https://overshoot.footprintnetwork.org/about-earth-overshoot-day/. Accessed: 04.05.2025.

[2] Binaebi Akah and Shaowen Bardzell. Empowering products: personal identity through the act of appropriation. In *CHI'10 Extended Abstracts on Human Factors in Computing Systems*, pages 4021–4026. Association for Computing Machinery, 2010.

[3] Fatemeh Alizadeh, Aikaterini Mniestri, Alarith Uhde, and Gunnar Stevens. On appropriation and nostalgic reminiscence of technology. In *CHI Conference on Human Factors in Computing Systems Extended Abstracts*, pages 1–6, 2022.

[4] Kristina Andersen and Ron Wakkary. The magic machine workshops: making personal design knowledge. In *Proceedings of the 2019 CHI conference on human factors in computing systems*, pages 1–13, 2019.

[5] James Auger. Speculative design: crafting the speculation. *Digital Creativity*, 24(1):11–35, 2013.

[6] Conny Bakker and Cheyenne Schuit. The long view: Exploring product lifetime extension. 2017.

[7] Conny Bakker, Feng Wang, Jaco Huisman, and Marcel Den Hollander. Products that go round: exploring product life extension through design. *Journal of cleaner Production*, 69:10–16, 2014.

[8] Eli Blevis. Sustainable interaction design: invention & disposal, renewal & reuse. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 503–512, 2007.

[9] James Alex Bonus, Alanna Peebles, Marie-Louise Mares, and Irene G Sarmiento. Look on the bright side (of media effects): Pokémon go as a catalyst for positive life experiences. *Media Psychology*, 21(2):263–287, 2018.

[10] Svetlana Boym. *The future of nostalgia*. Basic books, 2008.

[11] Brian Burns. Re-evaluating obsolescence and planning for it. In *Longer lasting products*, pages 39–60. Routledge, 2016.

[12] John Campopiano. Memory, temporality, & manifestations of our tech-nostalgia. *Preservation, Digital Technology & Culture (PDT&C)*, 43(3):75–85, 2014.

[13] Simran Chopra, Rachel E Clarke, Adrian K Clear, Sara Heitlinger, Ozge Dilaver, and Christina Vasiliou. Negotiating sustainable futures in communities through participatory speculative design and experiments in living. In *Proceedings of the 2022 CHI conference on human factors in computing systems*, pages 1–17, 2022.

[14] Tim Cooper. Inadequate life? evidence of consumer attitudes to product obsolescence. *Journal of Consumer Policy*, 27(4):421–449, 2004.

[15] Tim Cooper. Slower consumption reflections on product life spans and the "throw-away society". *Journal of industrial Ecology*, 9(1-2):51–67, 2005.

[16] Marcel C Den Hollander, Conny A Bakker, and Erik Jan Hultink. Product design in a circular economy: Development of a typology of key concepts and terms. *Journal of Industrial Ecology*, 21(3):517–525, 2017.

[17] Fabián Echegaray. Consumers' reactions to product obsolescence in emerging markets: the case of brazil. *Journal of Cleaner Production*, 134:191–203, 2016.

[18] Pedro Gil Farias, Roy Bendor, and Bregje F Van Eekelen. Social dreaming together: A critical exploration of participatory speculative design. In *Proceedings of the Participatory Design Conference 2022-Volume 2*, pages 147–154, 2022.

[19] Laura Forlano and Anijo Mathew. From design fiction to design friction: Speculative and participatory design of values-embedded urban technology. In *Urban Informatics*, pages 7–24. Routledge, 2017.

[20] Stephan Freundorfer. 25 jahre game boy in deutschland. `https://www.spiegel.de/netzwelt/games/25-jahre-game-boy-in-deutschland-a-1056277.html`, 2015. Accessed: 04.05.2025.

[21] Anne Galloway and Catherine Caudwell. Speculative design as research method: From answers to questions and "staying with the trouble". In *Undesign*, pages 85–96. Routledge, 2018.

[22] Jorge Graça. Between the winner's curse and the blessings of vintage. 2010.

[23] Catherine Grevet and Eric Gilbert. Piggyback prototyping: Using existing, large-scale social computing systems to prototype new ones. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, pages 4047–4056, 2015.

[24] Kristin Hanks, William Odom, David Roedl, and Eli Blevis. Sustainable millennials: attitudes towards sustainability and the material effects of interactive technologies. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 333–342, 2008.

[25] Ollie Hanton, Zichao Shen, Mike Fraser, and Anne Roudaut. Fabricatink: Personal fabrication of bespoke displays using electronic ink from upcycled e readers. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*, pages 1–15, 2022.

[26] David S Heineman. Public memory and gamer identity: Retrogaming as nostalgia. *Journal of Games Criticism*, 1(1):1–24, 2014.

[27] history tools. The history of the game boy: A complete guide. `https://www.historytools.org/products/the-history-of-the-game-boy-a-complete-guide?utm_source=chatgpt.com`, 2024. Accessed: 04.05.2025.

[28] Bruce Hood. Make recycled goods covetable. *Nature*, 531(7595):438–440, 2016.

[29] Elaine M Huang, Koji Yatani, Khai N Truong, Julie A Kientz, and Shwetak N Patel. Understanding mobile phone situated sustainability: the influence of local constraints and practices on transferability. *IEEE Pervasive Computing*, 8(01):46–53, 2009.

[30] Jina Huh, Kevin Nam, and Nikhil Sharma. Finding the lost treasure: understanding reuse of used computing devices. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 1875–1878, 2010.

[31] Maria Huusko, Yiying Wu, and Virpi Roto. Structuring and engaging: the roles of design fictions in a co-design workshop. In *Proceedings of the 30th Australian conference on computer-human interaction*, pages 234–241, 2018.

[32] Steven J Jackson and Laewoo Kang. Breakdown, obsolescence and reuse: Hci and the art of repair. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 449–458, 2014.

[33] Muztoba Ahmad Khan, Sameer Mittal, Shaun West, and Thorsten Wuest. Review on upgradability–a product lifetime extension strategy in the context of product service systems. *Journal of cleaner production*, 204:1154–1168, 2018.

[34] Sunyoung Kim and Eric Paulos. Practices in the creative reuse of e-waste. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 2395–2404, 2011.

[35] David Kindy. Thirty years ago, game boy changed the way america played video games. `https://www.smithsonianmag.com/innovation/thirty-`

years-ago-game-boy-changed-way-america-played-video-games-180972743/, 2019. Accessed: 04.05.2025.

[36] Eva Knutz and Thomas Markussen. The role of fiction in experiments within design, art & architecture-towards a new typology of design fiction. *Artifact: Journal of Design Practice*, 3(2):8–1, 2014.

[37] Bernard London. *Ending the Depression Through Planned Obsolescence*. 1932.

[38] Keza MacDonald. The game boy at 35: a portal to other magical worlds. https://www.theguardian.com/games/2024/apr/21/the-game-boy-at-35-a-portal-to-other-magical-worlds?, 2024. Accessed: 04.05.2025.

[39] Leah Maestri and Ron Wakkary. Understanding repair as a creative process of everyday design. In *Proceedings of the 8th ACM Conference on Creativity and Cognition*, pages 81–90, 2011.

[40] Mariesa Nicholas, Penny Hagen, Kitty Rahilly, and Nathalie Swainston. Using participatory design methods to engage the uninterested. In *Proceedings of the 12th Participatory Design Conference: Exploratory Papers, Workshop Descriptions, Industry Cases-Volume 2*, pages 121–124, 2012.

[41] William Odom, James Pierce, Erik Stolterman, and Eli Blevis. Understanding why we preserve some things and discard others in the context of interaction design. In *proceedings of the SIGCHI conference on human factors in computing systems*, pages 1053–1062, 2009.

[42] Daniela Petrelli and Steve Whittaker. Family memories in the home: contrasting physical and digital mementos. *Personal and Ubiquitous Computing*, 14:153–169, 2010.

[43] James Pierce and Eric Paulos. Second-hand interactions: investigating reacquisition and dispossession practices around domestic objects. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 2385–2394, 2011.

[44] Mike Plant. A timeline of game boy's record-breaking history as iconic console celebrates 30 years. https://www.guinnessworldrecords.com/news/2019/4/a-timeline-of-game-boys-record-breaking-history-as-iconic-console-celebrates-30-565921, 2019. Accessed: 04.05.2025.

[45] Hector Postigo. Of mods and modders: Chasing down the value of fan-based digital game modifications. *Games and culture*, 2(4):300–313, 2007.

[46] Foivos Psarommatis and Gökan May. Achieving global sustainability through sustainable product life cycle. In *IFIP International Conference on Advances in Production Management Systems*, pages 391–398. Springer, 2022.

[47] Christian Remy and Elaine M Huang. Addressing the obsolescence of end-user devices: Approaches from the field of sustainable hci. In *ICT innovations for sustainability*, pages 257–267. Springer, 2015.

[48] Sergio Rinaldi, Giorgio Frunzio, Mariateresa Guadagnuolo, Luciana Di Gennaro, and Luigi Massaro. A sustainable material for sustainable architecture: wood in parasite architecture. In *Congresso Internacional Sobre Patologia e Reabilitação Das Construções, Universidade Federal do Ceará*, pages 481–488, 2021.

[49] Kristin A Scott and S Todd Weaver. The intersection of sustainable consumption and anticonsumption: Repurposing to extend product life spans. *Journal of Public Policy & Marketing*, 37(2):291–305, 2018.

[50] Constantine Sedikides and Tim Wildschut. Finding meaning in nostalgia. *Review of general psychology*, 22(1):48–61, 2018.

[51] Constantine Sedikides, Tim Wildschut, Clay Routledge, Jamie Arndt, Erica G Hepper, and Xinyue Zhou. To nostalgize: Mixing memory with affect and desire. In *Advances in experimental social psychology*, volume 51, pages 189–273. Elsevier, 2015.

[52] Jaakko Suominen. The past as the future? nostalgia and retrogaming in digital culture. In *Proceedings of perthDAC2007. The 7th International Digital Arts and Cultures Conference. The Future of Digital Media Culture*. Citeseer, 2008.

[53] Theresa Jean Tanenbaum, Amanda M Williams, Audrey Desjardins, and Karen Tanenbaum. Democratizing technology: pleasure, utility and expressiveness in diy and maker practice. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 2603–2612, 2013.

[54] Patricia Van Loon, Derek Diener, and Steve Harris. Circular products and business models and environmental impact reductions: Current knowledge and knowledge gaps. *Journal of Cleaner Production*, 288:125627, 2021.

[55] Guri Verne and Ida Braaten. Participation for the unengaged. In *Proceedings of the 13th Participatory Design Conference: Short Papers, Industry Cases, Workshop Descriptions, Doctoral Consortium papers, and Keynote abstracts-Volume 2*, pages 1–4, 2014.

[56] Ron Wakkary, Audrey Desjardins, Sabrina Hauser, and Leah Maestri. A sustainable design fiction: Green practices. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 20(4):1–34, 2013.

[57] Ron Wakkary and Karen Tanenbaum. A sustainable identity: the creativity of an everyday designer. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 365–374, 2009.

[58] Harald Wieser, Nina Tröger, and Renate Hübner. The consumers' desired and expected product lifetimes. *Product Lifetimes And The Environment*, 2015.

[59] Jacob O Wobbrock and Julie A Kientz. Research contributions in human-computer interaction. *interactions*, 23(3):38–44, 2016.

[60] Tim Wulf and Matthew Baldwin. Being a kid again: Playing pokémon go contributes to wellbeing through nostalgia. *SCM Studies in Communication and Media*, 9(2):241–263, 2020.

[61] Tim Wulf, Nicholas D Bowman, Diana Rieger, John A Velez, and Johannes Breuer. Video games as time machines: Video game nostalgia and the success of retro gaming. *Media and Communication*, (2):60–68, 2018.