Human-Waste: Recycling in Social Contexts

Examining the Transformative Potential of

Collective, Haptic, Local, and Immediate Plastic Recycling Practices

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Abstract

Plastics offer significant material benefits, such as durability and versatility, yet their widespread use has led to severe environmental pollution and waste management challenges. This thesis develops alternative concepts for collaborative participation in recycling processes by examining existing waste management systems. Exploring the historical and material context of plastics, it investigates the role of making and hacking as transformative practices in waste revaluation. Drawing on theories from Discard Studies, Material Ecocriticism, and Valuation Studies, it applies methods to examine human-waste relationships and the shifting perception of objects between value and non-value. Practical investigations, including workshop-based experiments with polymer identification and machine-based interventions, provide hands-on insights into the material properties of discarded plastics. These experiments reveal their epistemic potential, leading to the introduction of novel archiving practices and knowledge structures that form an integrated methodology for artistic research and practice. Inspired by the Materialstudien of the Bauhaus Vorkurs, the workshop not only explores material engagement but also offers new insights for educational science, advocating for peer-learning scenarios. Through these approaches, this research fosters a socially transformative relationship with waste, emphasizing participation, design, and speculative material reuse. Findings are evaluated through participant feedback and workshop outcomes, contributing to a broader discussion on waste as both a challenge and an opportunity for sustainable futures and a material reality of the human experience.

Keywords: plastics-as-waste, plastics-as-material, recycling practices, object-value, re-valuation, maker-education, Materialübung, hacking, archival practices, collaborative recycling, liminality, matter, scavenger-gaze, transmattering, peer-learning, skillsharing in workshops

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1. Introduction

1.1. Why Plastics?

When discussing plastics, a polymer is the term of reference. The term *polymer* originates from the Greek language and can be translated to “many units”. Polymers are defined as large, complex molecules, also known as “macromolecules”, that are formed by the combination of numerous small, repeating molecules called monomers. These polymers can have either natural or synthetic origins. All plastics are synthetic polymers (Oraon et al., 2025). *Plastics* are not commonly defined chemically, they are rather a functional classification based on a property. Something being *plastic* refers to its deformability. Natural polymers, such as *cellulose,* are less pertinent to this discussion, and deformability is a crucial aspect of this work.

Therefore in the context of this thesis the term *plastics* will encompass synthetic polymers in general, enabling a broader discussion about their cultural implications. Plastics have become both a cornerstone of modern innovation and a symbol of environmental degradation. Following the success of the term *Anthropocene,* the argument for the *Plastocene* was compellingly presented (Preston, 2017), marking the invention and global industrialization of plastics. The term *Plastocene* also recognizes that its ubiquitous use will be discernible on a geological scale, as plastics residue can and will remain as fossil layers.

> “Every plastic item ever made remains in existence in some form or another and will continue to act on environments for millennia. The history of the base ingredient of plastics (petroleum) stretches back to previous geological epochs, and its legacy will outlive us all.”
>
> — Farrelly et al. (2021, p. 247)

The introduction of plastics transformed the course of industrialism globally and can be shown to be closely interwoven with modern capitalism. A core contribution was in the field of commerce. Plastics revolutionized packaging, enabling completely new scales of food storage and transportation.

Describing the history of fossil fuels at large, Malm (2016) identifies the use of fossil fuels in shipping in the “Steam Age” as the paradigmatic advantage in transportation for the

British Empire. The use of combustion to perform work is kicking off the colonial era with all its consequences. Today, historians refer to this shift from manual labor to machinized work as the first industrialization. The amount of work needed to transport goods was dramatically reduced, leading to an exponential growth in the scope and scale of transportation.

Plastics have transformed the world on a similar scale, with the same underlying mechanism: their widespread use inherently presents a social catalyst by reducing the dimensions of space and time by transforming work exponentially. Like refrigeration increases the duration where a type of food can be considered fresh, airtight plastic packaging dramatically slows food degradation, which has a huge impact on globalized transport considerations. Essentially, the efficiency gains and other effects reached through the use of plastics are so large that they can be viewed as transforming the world on a fundamental level - a paradigmatic shift.

> “Plastics have revolutionized our lives. They have made possible things such as smartphones, modern cars, and LCD screens that depend on the light weight, high strength, and electrical and thermal insulation of plastics. They have enabled the production of disposable surgical equipment that ensures sterility, thereby minimizing inter-patient disease transfer. Countless lives have been saved, and the use of antibiotics has been reduced, as a result of lower levels of post-operative infection. Plastics allow the minimization of food contamination by harmful bacteria and reduce food-borne illnesses. ...On the face of it, plastics are good...”
>
> — Farrelly et al. (2021, p. 1)

At its inception, the cultural perception of plastic was characterized by its allure and promise. It was hailed as a revolutionary material, possessing the ability to perform a wide range of tasks. Following the groundbreaking discovery of the first polymers, plastics experienced a meteoric rise in popularity, captivating the world with its versatility and potential.

Despite their convenience for both industry and consumers, plastics have been repeatedly demonstrated since the late 1970s to be responsible for a range of health concerns, while their persistent presence in numerous ecosystems also inflicts severe ecological damage (MacBride, 2012).

Today, more plastic than ever is being produced and discarded, with little sign of stopping (PlasticsEurope, 2018). With the widespread use of modern fabrication techniques like 3D printing, plastics as a production medium are now entering the realm of possibilities for many designers, enabling innovations and also new waste issues. As someone immersed in 3D printing, I frequently am confronted with sustainability challenges. Most 3D-printed parts are never recycled; instead, they contribute to the growing global waste problem. The 3D printer itself is indifferent to what it prints, concerned only with material purity and dimensional accuracy, yet the materials it uses often demand virgin plastic, perpetuating a cycle of consumption and waste. Germany, as one of the leading producers and consumers of plastics, exemplifies the systemic reliance on virgin materials (PlasticsEurope, 2018). Although some recycled filaments are available on the market, they are typically costlier and of lower quality, discouraging widespread adoption (Sun et al., 2020). This disparity highlights a fundamental issue: the economic infeasibility of a robust, scalable recycling process for plastics. The core challenge lies in identifying and separating materials efficiently — a technological and logistical hurdle not yet overcome (Volk et al., 2021).

Despite these technological challenges, the willingness of individuals to engage in recycling is evident. Yet, existing systems (policy and infrastructure) fall short of empowering individuals to recycle effectively (MacBride, 2012).

This disconnect raises the question: how can we reimagine the life-cycle of plastics, fostering both ecological sustainability and human agency? Samantha MacBride rightfully puts the focus on policy changes, changing infrastructure in a top-down approach (MacBride, 2012). In parallel to such a process, it is argued here that multiple pathways and opportunities should be explored. A bottom-up grassroots approach could overall prove less effective, but it is expected to give a bigger sense of agency to the recycling individual, complementing all efforts to ban and regulate plastics.

I need to stress here that policy changes, *do* work and should be the first priority. One often cited example is the UN Montreal Protocol to ban chlorofluorocarbons (CFCs) (United Nations Environment Programme, 1987). CFCs are chemicals used commonly in refrigeration, but also as aerosols in spray cans. At the time, the ozone hole had just been discovered and was growing at an alarming rate, which was found to be the case mainly due to the accelerating release of CFCs into the atmosphere. Most countries ratified the Protocol in the following years, bans were implemented nationally, substitutes found, and the ozone collapse mitigated. People should vote and exercise democratic power, but one might feel inclined to *also* bring their trash to small local recycling initiatives because it lets one feel better about oneself. It can offer a reclaimed agency, a sense of actively combating the effects of the ecological poly-crisis, where the enormous problem of plastics is just one among many (Spekkink et al., 2022). There is a distinct transformative potential in participatory citizenship, as seen for example in the repair-café initiatives independently popping up. Whenever these independent initiatives persist and network in a translocal fashion, that amounts not only to a movement, but can also lead to the formation of new institutions and enable permanent change (Spekkink et al., 2022).

The bottom-up direction of movement for sustainable change in recycling is manifold: notable examples are the New European Bauhaus (NEB) (European Commission, 2020) and the social-media-like movement Precious Plastics (Spekkink et al., 2022). While the European Commission drives and funds the former initiative, it employs a bottom-up approach through open calls, co-creation opportunities, and feedback mechanisms that enable a global community to shape its agenda. This approach promotes transdisciplinary collaboration and integrates local knowledge into its initiatives. Moreover, nearly half of the recognized NEB projects are self-organized and privately funded, underscoring the grassroots nature of the movement. The latter has existed since 2012 and evolved with little external help into an internationally renowned grassroots expert community dedicated to combating plastic waste. The initiative provides open-source designs for recycling machines that can be built and operated locally, empowering individuals and communities worldwide to transform plastic waste into valuable products. By 2023, Precious Plastic's local initiatives are present in over 100 countries, making it *translocal* as claimed by Spekkink et al. (2022). The authors identify both Repair Cafes and the Precious Plastics Initiative as citizen-driven, attributing large transformative potentials with cultural impact.

This thesis explores potential avenues for transformation by fusing theoretical insights with practical experimentation. By examining the intersections of human behavior in groups, waste infrastructure systems, and process design, it aims to uncover opportunities for a socially transformative relationship with plastics. The goal is to shift perspectives, treating plastics not as waste, but as a resource capable of storing enduring value. This perspectival shift will later be denoted as going from *plastics-as-waste* to *plastics-as-value*.

In the last three years, studying to become an artist myself, a constantly surfacing topic was that of creative resistance. The term "Counter-Hegemony" from Laclau & Mouffe (2001) stuck with me, expressing meaning-making against dominant norms. Relatedly, during a project researching fences, borders, and micro-nations, I stumbled on the anarchist concept of the *Temporary Autonomous Zone* (Bey, 2011). Both concepts invite their own forms of resisting hegemonial meaning-making. From such a perspective, it seems that overwriting *plastics-as-waste* in the collective memory is more involved than simply wiping an idea or a storage section somewhere and defining a new concept. Some unlearning is required and a significant effort, one involving overwriting the known, the existent, and the expected.

To this end, Material Ecocriticism[1] will provide helpful insight with its feminist perspective, using the *storied body* and the recognition of the necessary fusion of the ontologic and the epistemic into *onto-epistemology* following Barad (2007)[2].

This thesis aims to explore these intersections through a series of workshops and experiments that challenge the status quo of plastic waste infrastructure, while proposing alternatives relying on community-made mechanisms.

Capital-driven innovation, science and technology with "plastic-eating bugs" or other narrations of technological fixes and proper top-down legislation are still on the far horizon and might never give us resolve, as outlined in Section 2.2.1.1.

The Plastocene poses a wicked problem that requires knowledge and planning, but what kind of knowlege? And how do we plan for disposal processes far out of the scope of human temporal terms?

It is argued here that we want the knowledge to be shared to maximize participation effects and that a multitude of flexible knowledge frameworks is necessary to capture all

[1] see further investigations in Section 2.2.1.2 following Oppermann (2013)
[2] find further details in Section 2.2

potential contributions. Wikipedia contributors & Wikimedia Foundation (2001) accomplishes some of these goals, and it can be argued that the world with a collective knowledge-accumulating tool like Wikipedia is a better one for it. Due to its structure, it requires a vetted account, a peer-review system, and many more mechanisms to try to ensure epistemic rigidity. There are gender, race and also disparities in social status in the contributor's demographic (UNU-MERIT, 2010). Some impediment to an equitable distribution of contributions should therefore be acknowledged. Nevertheless, what if we could extract some of the semantic richness from the Wikipedia model and apply it to a more flexible and collaborative platform? With an all-too-present problem of plastics pollution and some first conceptual tools at hand, the question naturally arises of what could be done about it? In tandem with the didactic workshop setup, a unique methodological tool is being introduced that could aid in collective meaning-making.

With the backdrop of plastic waste as a global challenge, a collaborative workshop format is presented, which tries to change perspectives on plastic objects surrounding us and playfully explore whether a co-creative learning process can contribute to a change in behavior towards waste. To support the workshop, a novel archival practice is outlined and tested. In this work, that will be the Machine Archivist, a way of meaningfully contributing to persistent collective knowledge, removing some of the contribution barriers still posed in projects like Wikipedia. The archive is a semi-permanent knowledge structure, and able to be used both for teaching and documentation purposes. It enables a user to to completely forego or conveniently relay manual reflective processes, whether this is digital note-taking or an analogue archiving of results. The creative process is uninterrupted by "scientific housekeeping" while all data is still collected and aggregated in relational form.

1.2. The research hypothesis

Essentially, three problems are identified within this work:

1. Considering workshops as an educational format, how can they benefit from the notion of them being pure infrastructure, a scaffolding to support exploration?
2. What properties are needed for a given infrastructure to enable a re-narration of value in objects, here done on the example of plastics?[3]

[3] Further expanded in Section 2.2, see Bey (2011); Żyniewicz (2023)

3. How can we use the proposed tool-set on complex, wicked and multidimensional issues like *plastics-as-waste*? Being exposed to a faceted problem that cannot be tackled trough conventional problem-solving[4], are there benefits to be found in the presented approach?

These hypotheses suggest that working collaboratively, touching and transforming a material leads to novel insights and shifts in perceived agency, which are not attainable through other forms of learning. Capturing the knowledge generated in a communal setting such as a workshop and facilitating knowledge transfer to a usable, persistent state is recognized in the context of this thesis as a central challenge. Usual strategies rely on often insufficient and short-falling individual knowledge-capturing. Interactive formats like workshops offer vast learning efficiency benefits, but their relative contribution to persistent knowledge-generating processes at large, such as those in scientific communities, remains relatively insignificant.

In contrast to isolated documentation strategies, it is proposed that a pre-structured archival process is epistemically superior by attempting to systematize the effort of the documentation aspect from an artistic endeavor or other knowledge-generating collective formats. It hopes to sustain the benefits of conscious reflection, while automating any aspects hindering free associative play.

As an overall intent, it is to be demonstrated that the communal process in the proposed workshop format is not only capable of providing didactic or epistemic benefits, but is also able to offer evidence for a deeper ritualistic process; one that is capable of rewriting material narratives, reinventing material meaning, essentially a novel value-creation process.

I will set the theoretical framework of the thesis in Section 2, then I will talk about the rationale for the Workshop, its preparation, and present further documentation in Section 3. There, I will also introduce the novel implementation of the Machine Archivist to be found in Section 3.4. Finally, I will present the results of the workshop in Section 4 and discuss their implications in Section 5. The latter also features potential further work and determines the utility of the introduced concepts for education and research in general.

[4]Evidence provided in depth in Section 2.2.1.1, see Hird (2012)

2. Context

This section draws upon several existing concepts on trash and plastics, providing all the necessary tools to follow the conceptualization of the workshop and its process, as presented in Section 3.

2.1. Histories of valued matter

In the Following, the recent history of both plastics and trash as a whole will be examined in parallel, to help refining each concept. This initially separate and then combined examination will endeavour to trace and observe the commonly established, wicked perception of *plastics-as-waste*, which is often salient and dominates discourse, leaving no space for alternative perspectives.

2.1.1. History of Plastics

Bakelite was the first petrochemically derived plastic to be discovered and was quickly integrated into productive and consumptive processes. It was immediately recognized as the wonder-material it truly is (Montoya, 2024). After many worldwide experiments with casein, cellulite, and other malleable materials,[5] that could replace the expensive use of horn and bones as durable, yet moldable materials, Baekeland was the first to use pressure. He made the Bakelizer, a device that could apply pressure to a mixture of phenol and formaldehyde. On first success on June 20, 1907, he wrote:

> “A solidified matter, yellowish and hard ... This looks promising and it will be worthwhile to determine how far this mass ... is able to make molded materials, either alone or in conjunction with other solid materials, as for instance asbestos, casein, zinc oxide, starch, different inorganic powders and lamp black and thus make a substitute for celluloid and for hard rubber.”
>
> — Fenichell (1996, p.90)

[5]these were sometimes quite successful, like the celluloid film by Kodak that let the company rule the market for decades.

2.1.1. History of Plastics

Figure 1

A bakelite sellers catalogue from 1924

Note. [Wikimedia Commons: Early Bakelite]

The image is part of the public domain (Wikipedia contributors, 2025).

After Bakelite, industrial design transformed massively and fast: First came Cellophane, protecting Camels' precious cigars from moisture (Fenichell, 1996, p. 107), then Nylon in 1930, finally making cheaper stockings than silk (Fenichell, 1996, p. 135). Not long after, in 1940, Henry Ford saved a huge chunk of the available metal supply for the potential war effort by fabricating the first Ford-produced car chassis from Vinyl (Fenichell, 1996, p. 176). There is not a single area of consumption that has not been impacted by the advent of synthetic polymers. Although no synthetic polymers at all were produced before 1907, and only less than half a million tonnes were produced annually by 1950, by 2016, global plastics production reached 335 million tonnes per annum. (PlasticsEurope, 2018). The production of synthetic polymers has skyrocketed, becoming virtually interchangeable with the term "plastics". As a result, other types of plastics are typically distinguished with prefixes like "natural" or "bioplastics" (Farrelly et al., 2021, p. 2). As a consequence, or maybe also because plastics were so versatile and malleable, literally *plastic*, roughly half of the designs in the book "100 designs, 100 years: innovative designs of the 20th century" (Byars & Barré-Despond, 1999) are fabricated using synthetic polymers as their constitutive material.

Many of the devastating effects of plastics in our everyday life were then only slowly discovered in the 70s and 80s. The first major plastics pollution event reaching major public interest was the Great Pacific Garbage Patch, which was discovered in 1988 (Farrelly et al., 2021). The much-heralded durability of the new materials proved too much for us to stomach: Due to their chemical composition, plastics are not easily broken down by bacteria or other organisms, causing them to persist in the environment. By now it is abundantly clear that consuming plastics, and thereby microplastics as well as nanoplastics, is harmful and should be avoided by people and all living organisms (Farrelly et al., 2021). Despite numerous urgent scientific and political calls to collective action, by now we have no real choice in the matter, and non-human agents even less so: literally every animal tested so far at the bottom of the 10-kilometer-deep Mariana Trench, one of the most isolated places on Earth, was found to have ingested plastics (Jamieson et al., 2017).

Plastics are now a part of nature, contributing to often unpredictable ways of entanglement between human and nonhuman bodies, discourses, and materials. Plastics can no longer be presented as a lifeless and apolitical material. It is not inert; it is made matter, consisting of storied bodies.

2.1.2. History of Trash

In the Book “Müll: eine Schmutzige Geschichte der Menschheit” by“ Köster (2024), trash is shown to be closely intertwined with capitalism and the resulting overproduction of goods. Pre-capitalist societies did often not even have a concept of waste, as it was simply not a necessary concept. Waste was either not produced in the first place or it took a form that simply reintegrated into either a productive cycle or a natural process (Köster, 2024, p. 15). Köster also observes that trash is from its inception a valued category. It always comes with the association of “dirtiness”, devaluation and general repulsiveness (Köster, 2024, pp. 11ff).

In this context, he identifies scavenging specifically as a practice generating expert knowledge, with uniquely efficient techniques for identifying and isolating plastics and other waste not yet reproduced in industrialized contexts (Köster, 2024, pp. 298ff). Plastics transformed scavenging industries and also the dependent handiworks. Craft workers previously primarily working with scavenged metals quickly retrained and switched their working materials towards plastics, since they are in many regards more convenient, easier to scavenge and easier to form and also less resistant to DIY-Forms of recycling (Köster, 2024, pp. 298ff).

When it comes to recycling as a whole, the practice is historically strongly aligned with the available infrastructure for it. Glass has one of the highest recycling rates worldwide, which is not only explained through material properties, but also because it has a long history of politics establishing infrastructures for collection and recirculation (Köster, 2024, pp. 293ff). With plastics, this infrastructure took particularly long to establish because of the sheer variety and lack of regulation at the point of production. A prominent German example is the “Grüner Punkt”, which got established in 1990 and had an especially hard time growing the support necessary from a larger population in order to be effective. Once established, infrastructures developed a performativity that turned recycling into a widespread behavior in the first place: the glass container served as a daily reminder of the possibility of reuse. A similar effect occurred later with the various bins made available to citizens. Ultimately, it was this everyday presence that made recycling increasingly indispensable. (Köster, 2024, p. 293)[6].

Extrapolating this historical overview, a resulting workshop conceptualization would impose certain design constraints. The workshop itself should be understood as a form of infrastructure. It will provide performative transformation through providing a space for exploration, without the need for a full education in material science. It is posited that the guided and playful contact with the material itself is enough to change perceptions and create appreciation on a material level.

2.2. Concepts for re-narration of object-value

Apart from looking at the historic origins of *plastics-as-waste*, there are several other concepts helping to shape the proposed workshop as an educational format.

Thompson’s *Rubbish Theory* challenges the notion of inherent value, proposing that objects transition between *transient*, *durable*, and *rubbish* categories through social and economic processes. Waste, often dismissed as valueless, can regain worth when cultural perceptions shift, enabling its transformation into something durable. This perspective aligns with Hird’s argument that waste resists containment, requiring a nuanced

[6] a similar development can be observed in another, more US-centric publication: “Waste and Want” (Strasser, 2000)

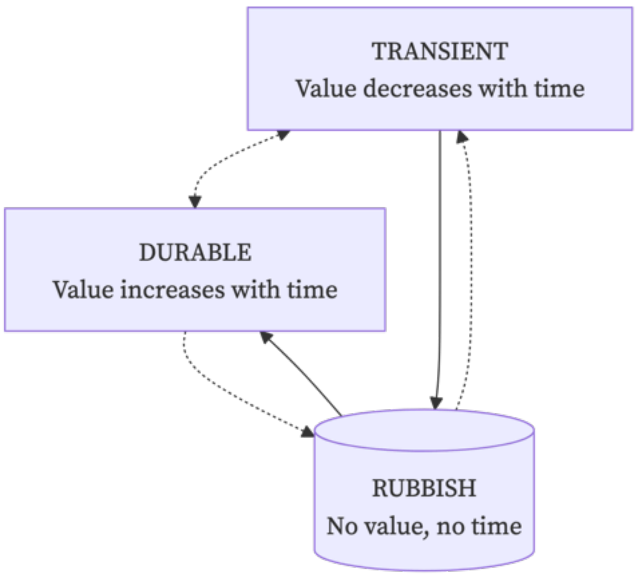
understanding beyond technological fixes. Material Ecocriticism further extends this by emphasizing the *storied* nature of matter — objects carry meaning which evolves through narrative and context. Concepts like *transmattering* and *liminality* highlight how discarded materials can be reimagined, while the *Temporary Autonomous Zone* illustrates how shifting social spaces enable new valuations. These ideas inform counter-hegemonial practices like dumpster diving and together with Bauhaus *Materialstudien*, demonstrate that revaluation is a creative, performative act that challenges consumer capitalism and fosters sustainable material engagement.

2.2.1. Rubbish Theory

In the Book "Rubbish Theory" by Thompson (2017) the author argues that the value of an object is not inherent to the object itself, but rather a social construct. This is especially true for waste, which is often considered valueless and disposable. However, Thompson contends that waste can be transformed into value through social, cultural, and economic processes. By reevaluating our perceptions of waste and its potential, we can create new systems of value that promote sustainability and resourcefulness.

Figure 2

Object value classes and their transition options following Rubbish Theory



Note. Rubbish theory adds *Rubbish* as a Value-Class and proposes that it enables the transition from transient to durable, which was previously not explained (Thompson, 2017). Image adapted from Thompson (2017, p.4).

2.2.1. Rubbish Theory

The Book establishes three fundamental value classes, transient, durable and rubbish. It is worth noting that the categories *transient* and *durable* are not new here, they have been discussed in design theories for quite a while (Thompson, 2017).

A transient object is an object expected to decrease in value over time, while a durable object is expected to increase in value over time. The third category, rubbish, is the novel concept introduced here. Objects are not permanently tied to each category. Instead, they can change their value-class based on occasion and social interpretation, as shown in this example: Someone might bring an old nightstand of their grandparents to the recycling station, another person might find that nightstand in a secondhand store and enjoy it for many more years because along the transaction chain anybody decided this object is worth more than it seems. Perhaps, at some point that nightstand survived long enough to be a "vintage", an object well worth preserving. If the circumstances allow, that nightstand might even increase in value, perhaps because in the meantime it has become symbolic for a now-gone epoch. And while objects go from durable to transient all the time, for example by breaking, it is the other direction though, which is the more interesting one: going from transient to valuable. This is a class traversal that is hard to predict and whose mechanics are not trivially explained. Thompson's central argument is that rubbish is the missing link here, the thing that enables a value-class traversal from transient to durable. At some magical point a lunatic collecting an obscure oddity convinces a critical mass of others that there is reason in collecting that object, an inherent value. They follow suit and a valuable object is created. One could say he essentially described the stock market, operating on a similar notion of value.

Upon this basic theorem by Thompson, that something has to first be occluded, forgotten, trashed, before it can ascend as a durable, a whole field of study came to be: the discard studies. Discard Studies as a field examines the social aspects of waste, pollution, and externalities, providing critical insights into how societal practices contribute to plastic waste generation and management (Hird, 2012).

Knowing Waste.

Hird can bring concepts from feminist epistemology to the discussion, helping to dissect the "twilight category" of waste as something that is necessarily ill-defined with reference to Haraway's *Cyborg* (Haraway, 1990).

According to Hird, waste is not technologically containable. It fails to be determined, to be predicted, to be categorized. The only way waste seems to be feasibly contained is through human norms and social practices. Knowing waste and dissecting it at the intersection of determinacy and indeterminacy, recognizing its *entangled* nature is therefore a necessity for our survival. Blindly interfering in a complex network of interdependencies will necessarily only produce temporary solutions, requiring a different kind of analysis than traditionally applied (Hird, 2012). One principal component in the analysis is Barad's *onto-epistemology* (Barad, 2007), later discussed in Section 2.2.1.2.

Hird makes a thorough case for the necessarily failing option of techno-solutionism. Since waste is a non-category, entirely negatively defined as the not-want, any rationalistic containment policy will fail to contain it. Instead, it is entangled, posing an epistemic problem for any intended solution.

> "The problem with landfills is that their containment is always temporal; eventually they spill and leak. Engineers design, model and text complex technologies for leachate containment, and then describe the consequences of landfill corruption and failure. Successful landfill design and aftercare, in engineering terms, extends to perhaps one hundred years, a mere moment in geological and bacterial time. ... Current environmental and health concerns with exhuming landfills for once discarded and now valued material, are a reminder of waste's ephemerality as waste, of *knowing* waste."
>
> — Hird (2012, p. 465)

For the workshop that would entail that it would need to go beyond teaching the participants how to recycle, but to fundamentally change their relationship to waste and the materials around them. It tries to mimic and explore the shift in perspective needed to go from *plastics-as-waste* to *plastics-as-value*.

Material Ecocriticism. Material Ecocriticism, originating from feminist social sciences and literature studies, introduces the concept of *storied bodies*.

2.2.1. Rubbish Theory

> "All matter, in other words, is a "storied matter." It is a material "mesh" of meanings, properties, and processes, in which human and nonhuman players are interlocked in networks that produce undeniable signifying forces."
>
> — Iovino & Oppermann (2014, p.2)

Humans and objects are both considered storied bodies in this framework. As material beings inhabiting a material world, we are intrinsically connected to this concept. Storytelling can thereby reframe and reinfluence everything (Phillips & Sullivan, 2012).

> "Nevertheless, our capacity for storytelling and tool-making serves to extend our material bodies and the material processes in which they are enmeshed, not to sever us from them. We extend our material lives and bodies, and thereby we also extend and increase our material impact — which is to say we have never been immaterial since we first appeared on Earth, and will always be material so long as we remain here."
>
> — Phillips & Sullivan (2012, p.447)

We can examine the *narrativity* of matter—bodies, nature, and cultural forms, because the meanings it carries are inherently connected to us. As participants in these *confederations* of diverse material compositions, we are intertwined with their material agency, co-emerging as beings shaped by stories. If humans are the fruit of the world's unfolding, this perspective offers a way to actively engage in "bringing forth the world in its specificity, including ourselves" (Barad, 2007).

This is our way to combine materiality with the epistemic, as Barad would say:

> "to meet the universe halfway, to move toward what may come to be in ways that are accountable for our part in the world's differential becoming."
>
> — Barad (2007, p. 353)

2.2.2. Transmattering

In the PHD thesis publication, "TRANSMATTERING IN THE MAKING" (Żyniewicz, 2023) the author introduces the term *transmattering* as a novel contribution, which describes a methodology of transforming matter with their respective attached meaning, building upon the *storied bodies*, a central tool in the field of material Ecocriticism, building on Karen Barad and Serpil Oppermann, as introduced in Section 2.2.1.2.

Matter and meaning are intertwined (Barad, 2007), meaning Ontology and Epistemology are not very intelligible as separate entities. Barad introduces *onto-epistemology* to capture that idea. If we then want to transform one storied body into another, we are not only performing an ontological operation, we are performing a narrative operation alongside. For that to succeed, an object needs to have a certain disposition for transmattering, a narrative reformulation. This disposition is maybe best found in the concept of the *liminal*, loosely following Thompsons *rubbish* introduction, describing something occluded, or in the background of other things. Waste, and therefore *plastics-as-waste* is potentially a liminal category, if we can approach it as such.

2.2.3. Liminality in object and space

What then, is a liminal object?

> "The dissolution of order during Liminality creates a fluid, malleable situation that enables new institutions and customs to become established."
>
> — Szakolczai (2015)

Liminality describes two things: It understands something to be in the background of something else, in a kind of forgotten state, and it also describes something to be hybrid, of malleable, uncertain status, like it is still to be decided. For a more detailed discussion of the term, please refer to Thomassen (2009)

> "Liminality refers to moments or periods of transition during which the normal limits to thought, self-understanding and behavior are relaxed, opening the way to novelty and imagination, construction and destruction."
>
> — Thomassen (2016)

I understand the liminal as capturing the leftovers of what is meant in traditional Phenomenology by Bracketing, or the *epoché* (Husserl). Feminist thinkers have long dissected the impossibility of that concept and instead focused on the *other*, the *bracketed away* (Ahmed, 2007), the liminal as a useful epistemological tool.

In Żyniewicz (2023) the observer, the scientist, the acting human has to be liminal in order to perform the transmattering. The individual must shed labels, definitions, dogmas, and preconceptions of themselves and the world, which is likely an ideal state for the world-building taking place in Section 2.2.3.1.

The T.A.Z - Temporary Autonomous Zone - a liminal space?.

In the admittedly hard to follow musings about the Temporary Autonomous Zone (T.A.Z.) by the anarchist Peter Lamborn Wilson, under the pseudonym of Hakim Bey, (Bey, 2011) we can glimpse something like a liminal space too: The author creates a kind of performative spatiotemporal zone, where norms and hegemonial concepts are suspended. One could say, I believe, that "suspension of disbelief", a term used to describe narrative world-building in media, is a similar concept. Without a definition of a TAZ, which Bey intentionally refrained from, he wishes us to generate our own performative autonomous zone. The general concept there is a tactical one: It is a collective act, which results in the construction of a meta-space, defying any and all structures of control. It is ontological rebellion, as a narrative act.

> "The TAZ is like an uprising which does not engage directly with the State, a guerrilla operation which liberates an area (of land, of time, of imagination) and then dissolves itself to re-form elsewhere/elsewhen, before the State can crush it. Because the State is concerned primarily with Simulation rather than substance, the TAZ can "occupy" these areas clandestinely and carry on its festal purposes for quite a while in relative peace. Perhaps certain small TAZs have lasted whole lifetimes because they went unnoticed, like hillbilly enclaves — because they never intersected with the Spectacle, never appeared outside that real life which is invisible to the agents of Simulation."
>
> — Bey (2011, Waiting for the Revolution)

I would argue it is a liminal space, where semantics are dismantled, leaving space for the liberated creation of meaning. Bey denotes this as the *Pirate Utopia* crucial for political world-building, but I believe it serves as well as an Artistic Utopia, a liminal zone where objects can be revisited for the first time, yielding a unique opportunity for narrative creation. Bey also recognizes here the same precondition appearing throughout all ideas so far: Something has to be trashed to be picked up, it has to first be bracketed away, forgotten, squeezed empty of old meaning before it can readily take on a new one.

It adds for us the dimension of the space, the situation, the context. Some zones are better suited for autonomous, counter-hegemonial meaning-creation than others, and they can be intentionally performed.

What the Liminal can contribute. The liminal object is a similar category as *rubbish* by Thompson (2017), but it encompasses more than only trash and thereby opens up the opportunity for a material-as-such to already undergo the desired transfer from transient to durable. The liminal object can be understood as an intermediary state between waste and art, where the material itself is not necessarily discarded but rather transformed into something new.

The liminal does even more for us: it does not only create the preconditions for re-narrating an object into an object of more value, which in itself already amounts to alchemy; it also gives us a tool to grasp why communal Liminality is such a powerful mechanism: it gives us authorship and agency, a sensation of being in charge of a creative process, of being able to manipulate what is not manipulatable.

The liminal is also a scary place: humans are habitual, getting robbed of habits, of norms, of established meaning is not by default a beautiful, or productive experience. The meaning created in a specific communal context is an elevated meaning, a sort of ritual. It is tied to its context, enriched by it, entangled with it. Taking the storied-object out of there, packaging it, transferring it to another context is a delicate matter.

Hacking Value: on actively bettering through scavenging.

To examine what other practical options are left to actively transform value, we should also look at dumpster-diving.

In their article on valuation studies “From Trash to Treasure” (Lehtonen & Pyyhtinen, 2020), the authors discuss ways to re-valuate waste yet in another practice. By using dumpster-diving for food as a methodological example, they use Georg Simmel’s theory of value and Gilles Deleuze’s virtuality/actuality to create the *scavenger gaze*.

> “The gaze always implicates the craft of scavenging, and both the gaze and the craft, in turn, rely on the use of various objects as technological prostheses. In the following section, we move from the practicalities of dumpster diving to examining how dumpster divers value not only waste matter but also the practice itself in a way that is

> different from the way surrounding society does. They take pride in doing good and see themselves as accomplishing something respectable and significant."
>
> — Lehtonen & Pyyhtinen (2020, p. 199)

Dumpster diving serves as a valuable research site for understanding the fluid nature of waste, revealing how discarded objects can regain value and cease to be waste. It highlights that re-commodification is not the only way for discarded items to be repurposed; instead, they may find new life through personal use, gifting, or storage.

The practice of dumpster diving sheds light on how the valuation of waste is hacking broader social, ethical, and economic values, challenging consumer capitalism and framing the practice as a meaningful, value-laden act. Value, here is a *pragmatic* definition, it is not an attribute of the object at all, it is "enacted in practical relations" (p. 201). As a consequence, the enacted de-valuation that created the waste can only be turned around with an intentional practice of re-valuation. Unlike the scavengers mentioned in Section 2.1.2, the questioned dumpster-diving people in the performed study were academics in Finland:

> "Our informants could afford to buy their food, but they chose to scavenge mainly for ideological reasons: they are critical of overconsumption, the ethos of disposal, and the wasting of resources in capitalist production."
>
> — Lehtonen & Pyyhtinen (2020, p.201)

Apart from displaying a human tendency to try to increase value in the world in non-capitalist ways, this study again focuses on the holistic character of this practice practice; the authors recognize a performative element, a special skill-set and a communal behavior that is desirable to pursue.

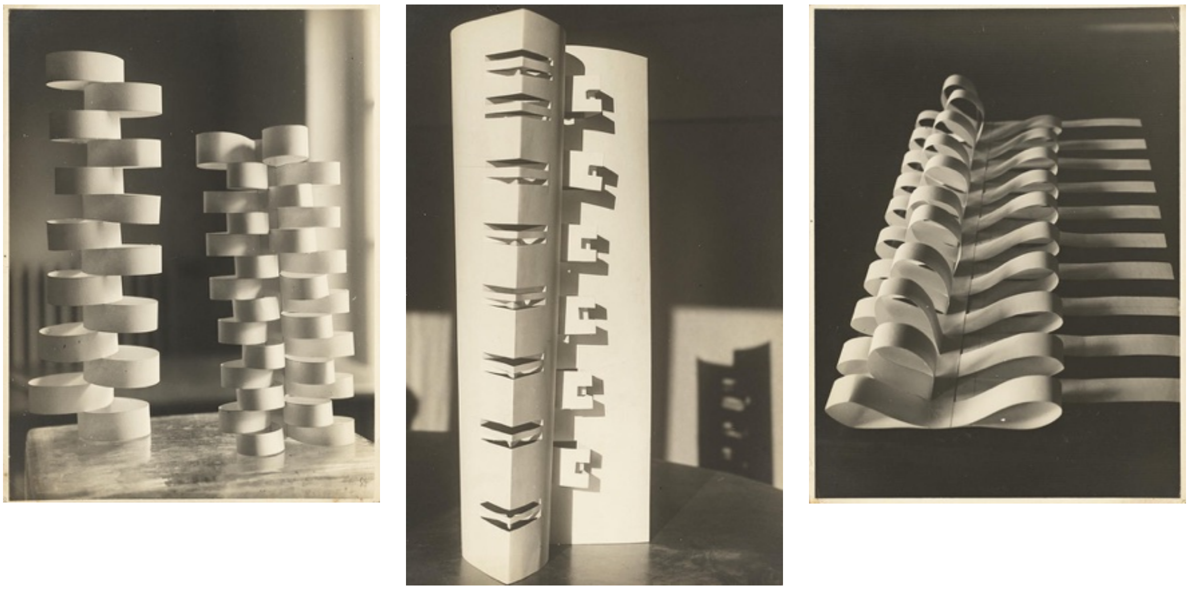
I find the word "hacking" of particular use here, as that is what it is: breaking conventions, finding alternate routes, addressing structural problems in a system. A scavenger and a hacker, at the very least, share the same ill-defined interdisciplinary skill set.

2.2.4. A Bauhaus Example: Materialstudien

As visible in Figure 3, already the 1920s Bauhaus movement pioneered the idea that it might be a pedagogically useful exercise to restrict oneself to a certain set of materials, in order to explore the very base attributes of it. This aims at training a specific artistic gaze, that can be universally applied to problems, conceptually similar to the *scavenger gaze* introduced earlier. The Bauhaus tradition differentiates between “Materiestudien” and “Materialstudien”, the former instigating students to look at the base properties of a material, to facilitate choosing the right material for specific tasks, while in the “Materialstudien”, somtimes also “Materialübungen”, the students got consciously restricted to a single material to bring about novel and unexpected applications of it (Engels, 2021).

Figure 3

Some results from the Bauhaus Vorkurs under Albers



Note. All three images are photographed by Alfred Ehrhardt (1928, n.d., artist unknown) Reproduced with friendly permission by the [Alfred Ehrhardt Stiftung](https://).

The Bauhaus Vorkurs is an especially valuable reference, because it is an early example of how the Bauhaus movement sought to instigate students to creatively and productively explore the very base attributes of materials. The Vorkurs is a foundational course that introduces students to the fundamental principles of design and aesthetics, including the study of materials. Plastics, a material prone to be subject to the *plastics-as-waste* perspective, is thereby given a renewed focus and is encouraged to be explored through the lens of both aesthetics and functionality. It is given a shiny place on the central stage reserved for materials worthy of artisanship. Considering plastics at all as an artistic material is elevating it’s cultural status and re-writing it’s potential; it makes tangible to the individual why the industry decides on it's use on so many occasions. Plastics have amazing material properties and are much more accessible than people might think, both in terms of availability (trash) and in terms of malleability as presented earlier.

The present workshop adopts this approach by focusing on the material properties of plastics, encouraging unconventional uses and applications that challenge conventional perceptions thereof. Here, exploration of techniques is fostered through a specific selection of tools presented to participants. Effectively, a material study is conducted, where we focus on recycled plastic waste as the sole material as a constraint. In exchange, we leave full personal autonomy in workflow design and choice of method.

Again, the same erase-play-learn strategy already discovered in Section 2.2.3.1 surfaces:

> "First, students were taught to erase their minds of preconceptions so they could explore their own responses to form in relation to the world about them. They gained knowledge of materials through play. In their explorations, they focused on learning timeless design principles."
>
> — Lerner (2005, p. 224)

A former Bauhaus student describes the task, when given the materials, as:

> "...just *basteln*, or play around with them, to see if we could make something out of them or discover something about them."
>
> — Lerner (2005, p. 218)

We can see here formulated, a task not primarily designed to learn about attributes of materials, we are dealing with a multilayered educative methodology, where the primary object of exploration is one of *how* to explore.

A modern Example.

Although Studio Anne Holtrop utilizes a different material, much of the methodology is already contained therein. A noteworthy addition here is the material database created during the course. This emphasizes the need for some kind of knowledge aggregator which will be the topic in the next Section 2.2.5.

> "In this studio, we will focus on the unique gestures dictated by a particular material and the specialisms of working that material in what we call 'material gesture'. We will

explore the making in relation to a material in order to produce an architecture that is solely focused on the relationship between the two. Our interest in the material will be related to its properties, how it is mined, its use in industry, its effect on craftsmanship, specialized fabrication techniques, its cultural significance, and innovations in the field of architecture. The research that is carried out in the studio will be largely developed through a practice-based approach, and applied throughout the intrinsic developments of the projects in the design studio. Each semester, a subtopic within material gesture will be explored ranging from an in-depth focus on one specific source material - gypsum, to the geological interest of a site, and the man-made materials from our current geological age, the Anthropocene. The results will be collected in a growing physical database of materials, and its performance through its applications in the form of large architectural models, made in the actual researched materials and techniques."

— Anne Holtrop (*Material Gesture*, 2024)

2.2.5. The problem of archiving

In a learning process, even more so an artistic learning process, making knowledge persistent is a hard problem. It is one thing to learn and study for a test and entirely another to transmit experiential and haptic knowledge. All the little details found out during handling a material and intentionally transforming it, are very often lost in the transition from one person to another. We are social learners and doing something in a group already significantly changes the learning experience through feedback mechanisms (Sheridan et al., 2014). But then again it becomes an organizational problem of collective learning: How do we harvest the marvelous diversity of approaches to a set of problems? How can we capture and utilize the superior epistemic position of a (diverse) group in a workshop context and create structured and persistent knowledge? An archival process is necessary. Such a process will be used in the workshop and is discussed in Section 3.4.

Anne Holtrop's studio, with its deep examination of the relationship between material and architecture, underscores the need for an archive. The creation of a growing material database is a step towards preserving both the tangible and intangible aspects of craftsmanship and experimentation. Such an archive would not only consolidate this knowledge but ensure its continued accessibility and evolution. It would be more than a static collection; it would become an evolving tool for learning and dialogue.

3. The Workshop: a scaffolding for collective investigation

A workshop format and a tailored methodology were desired outcomes from the early conceptualization phase of the thesis research. A peer-to-peer workshop, a ritualized communal learning experience, proved ideal for experimenting with novel knowledge-accumulation formats.

This chapter has to do some heavy lifting: first, the initial thought process and development of this format are laid out in Section 3.1, after which the intent is formulated in Section 3.2. Moving forward, all tools, workstations, and their configurations are presented in Section 3.3.1. Afterwards, a closer inspection of another central element, the Machine Archivist, in its duality as the physical extension, the UploadStation (Section 3.3.1.2), and the Software enabling it (Section 3.4) is warranted. Only then, the Workshop contents and process will be shown in Section 3.5.

The three component parts, the physical setup, the Machine Archivist and the structure of the workshop only form a cohesive picture of the workshop together and are as such, not easily separated.

3.1. A history of making: the workshop genesis

As already mentioned in Section 1, initially, the intention was to create a machine workflow, that enables the user to 3D print using exclusively self-recycled plastics[7]. In 3D printing, Fused-Deposition-Modelling (FDM) printers are most widely available. This printer type depends on filament, a long strand of plastics, usually rolled onto a spool. Consequently, a mechanism capable of producing this filament was to be developed. To create filament, an *Extruder* is needed, a machine using a screw to feed plastics pellets into a heated chamber pressing the melted plastic through a die, much like how pasta is made. To achieve results resembling virgin plastics-pellets used in the industry, the usual plastic waste comes in pieces too big to work with. A uniform particle size, around 5mm, is desirable and best achieved using a plastic shredder.

Plastic shredding is not a straightforward process, especially for hobbyists. Many researchers attempt to re-purpose paper shredders, but the results are mixed, due to the exceptional durability of plastics. In 2019, I fabricated this shredder according to plans from

[7] The initial idea was created around this Video: (Kitchen, 2018)

Precious Plastic (2025) with a research project idea centered around filament extrusion in mind. The primary objective there was to obtain a granular uniformity sufficient for use in conjunction with the Filastruder by Elmore (2013). The goal was to integrate a micro-controller into the extrusion process to automate the plastic extrusion and better control quality parameters. This automation would be beneficial, as extrusion demands an exceptionally high level of accuracy and consistency[8].

The Filastruder offered by Elmore (2013) wrote history for being the first commercially available filament extruder achieving a price-point under 1000 Euro, contributing to a democratization of production processes. The sensitive process of laser-based filament detection and measurement makes it susceptible to various factors, including wind and temperature fluctuations. Additionally, it is also affected by changes in light conditions. An automated solution proved to be a challenging task without a dedicated workspace setup that could be light-controlled. For the purposes of a participatory workshop, I ultimately opted for plate fabrication, although Recycling-to-Filament presents an intriguing and frequently addressed research challenge (Mikula et al., 2021). In didactic contexts, workflows must be resilient, and simplicity often prevails in this regard. A process involving sheets does slightly restrict the scope of potential research compared to a process that enables 3D printing in a truly circular manner. However, the simpler and even child-friendly sheet process compensates for this limitation.

Another open parameter is the question of the product to be created throughout the workshop. Something has to be made out of the materials in the workshop and this *something* is ideally viewed as unequivocally having greater value than what the materials had before. An object can only ascend to a *durable* status if enough people decide it is worth keeping, as seen in Figure 2. Consequently, a significant weight of decision-making is presented: what can we create that surpasses the value of the material it is constructed from?

After not being able to come up with a convincing answer, and through some processual feedback by the team from InKüLe, I found the practice of the Materialstudien described in Section 2.2.4. This laid the foundation for the conceptual framework that currently exists: A

[8]The current industry-standard tolerances stipulate no greater diameter deviations than 0.05 millimeters.

workshop primarily serves as a learning experience and a tool for acquiring knowledge. Could the knowledge generated during the workshop be the source of value for the object created? The planning shifted from the need to create objects that people might find useful (which is where I perceive value) towards considering how to capture and materialize the knowledge. Working with plastics, particularly in the manner proposed here, appears to be quite artisanal. Touching and deforming molten plastic necessitates an intimate and experiential knowledge that is less prevalent workflows centered around 3D printing a purely digitally modeled file.

Plastics exhibit diverse crafting capabilities, sometimes exhibiting properties akin to wood, iron, or glass. However, we rarely consider plastics in this manner, as their widespread presence emerged only during and after the contemporary industrial era. The artful manipulation of wood or stone predates the artful manipulation of synthetic polymers. It is rarely associated with artisanship. Plastics must catch up to a vast body of traditionalized material knowledge that has been transmitted over many centuries. Furthermore, plastics production relies on often socially invisible processes within the industrial sector which are on top usually associated with massive production scales not available to laypeople or individuals. Consequently, viewing plastics as malleable, craftable, and manipulatable in a way that is not completely machine-mediated like in 3D printing may not be particularly relevant to artists and necessitates careful introduction.

How can we *craft* plastics? How deform them? How can we *transmatter* them and attribute novel meaning?

3.2. Intent and constituting elements

As outlined in Section 1, plastics pollution is one of the most pressing environmental challenges of our time, yet recycling processes are often monopolized by industrial systems that prioritize economic efficiency over ecological sustainability. The ReShaping Plastics workshop offers participants hands-on experience in recycling and repurposing plastic waste as a valuable resource. By engaging in these activities, participants develop a sense of empowerment and contribute to addressing a pressing global issue. This workshop is open to participants from all disciplines, requiring no prior experience. Over the course of two sessions, participants will learn to construct a DIY plastic sheet press and explore innovative methods for transformation of plastics. The small group size of 10 participants ensures an intimate, collaborative environment tailored to the capabilities of the tools provided.

The workshop encourages a shift in perspective, treating plastic not as disposable waste but as a versatile material capable of new forms and functions. By engaging directly with the processes of sorting, shredding, heating, and molding plastic waste, participants will gain practical skills and insights into sustainable design practices and circular economies.

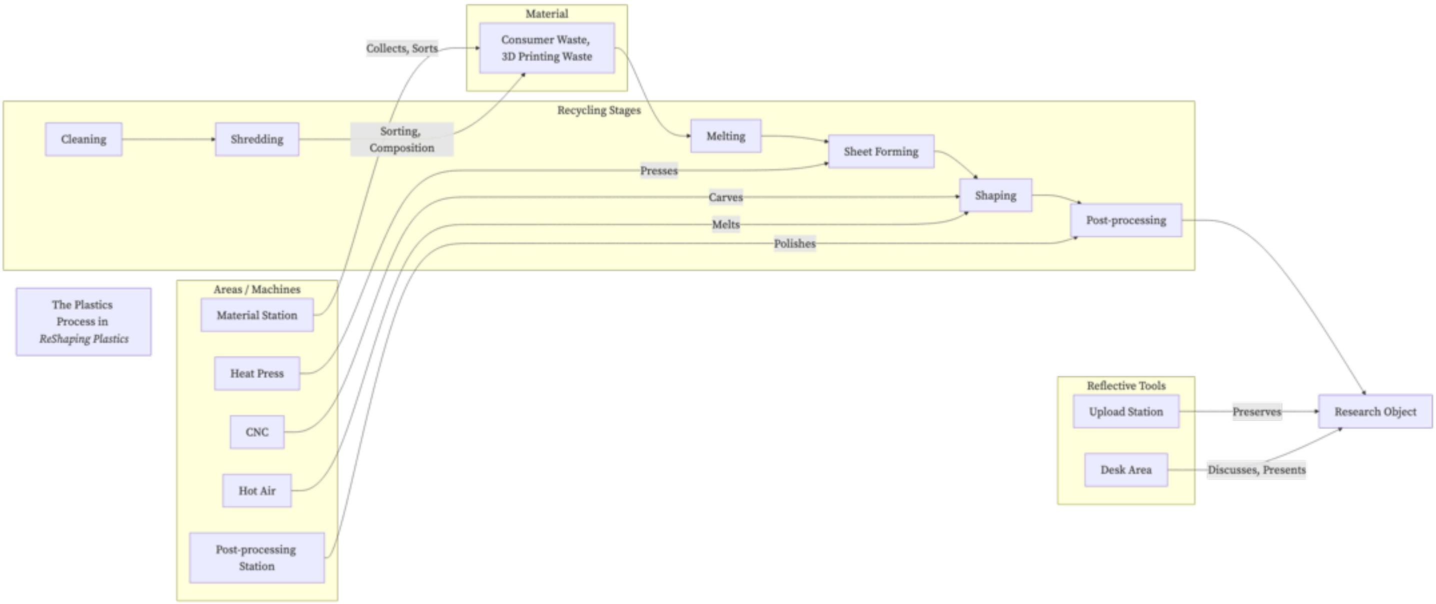
Participants will leave with a deeper understanding of plastics' life cycle and the tools to advocate for and contribute to ecological innovation in their communities, potentially transmattering methods and workflows in novel ways afterwards. This is not just a workshop on recycling — it's an opportunity to rethink waste, create tangible solutions, and spark a broader dialogue on sustainability and material culture.

The proposed workshop can foster experimentation and leave breathing room for the unexpected. It's an opportunity to explore new ideas, test hypotheses, and refine processes in a collaborative environment. It is set up around a loose network of research tasks, while its main contribution is the provision of infrastructure, both technical and conceptual - which this research is examining. The format provides access to the Machine Archivist described in Section 3.4, and also enables prestructured access to a host of Workstations and Machines laid out in Section 3.3.

In the following graph, Figure 4 a rough process outline from a machine perspective is given, enabling a high-level overview of the route the plastic will undergo. This scheme is not complete, as it only represents one possible workflow out of a set of many. Yet, it can help localize the machines in the this configuration, as they are each inspected more closely in Section 3.3.2.

Figure 4

The specific plastic recycling process in the workshop.



Note. Plastic recycling is a complex, multi-step process. It involves several stages, and on an industry scale, many different pathways are established. For a good overview of different industrial pathways see Volk et al. (2021). Presented for this work is an adapted workflow that incorporates feasibility in smaller scales and is designed with the machinery and PPE process at hand in mind. *Image Credit: Graph by the author.*

3.3. Setup and Machines

The workshop concept hinges on the quick availability of machines that can be easily transported and set up at various locations. A central constraint is portability, as the workshop should be able to adapt to different spaces and contexts without requiring extensive infrastructure or setup time. As a consequence, everything was built on wheels, also enabling restructuring on the fly and reacting to immediate communal needs. As the workshop cannot consist exclusively on the hands-on transforming of plastics, other areas, accomodating discourse and documentation are presented here alongside, all together forming the workshops infrastructure.

The workshop's core components, marked out as areas, include:

- The Desk Area (Section 3.3.1.1)
- Upload Station (Section 3.3.1.2)
- The Machine Section (Section 3.3.2), consisting of:

- ◦ The Shredder (Section 3.3.2.1)
- ◦ The Material Station (Section 3.3.2.2)
- ◦ Heat Area (Section 3.3.2.3)
- ◦ CNC Station (Section 3.3.2.4)
- ◦ Post-Processing Area (Section 3.3.2.5)

3.3.1. Areas and Stations

Within the setup, a clear zoning was pursued to cleanly separate different types of work areas. All activities are intentionally conducted within the same room to facilitate flow and collaboration. The stations are designed to be modular and easily reconfigurable. Firstly, it is logical to divide into the desk area (Section 3.3.1.1) and the workshop area, which houses all infrastructure for actively transforming plastics. Adjacent to the desk area is also the UploadStation, as described in Section 3.3.1.2. Regularly alternating between these three fundamental pillars of knowledge creation leverages each infrastructure's strengths and guides individuals towards either reflective or active states without explicit instructions. This enables us to fluidly transition between all areas of an *explore-reflect-adapt* triangle in an iterative manner.

In the following, each zone is laid out in more detail.

Enabling Sharing: the desk area.

A central element that unifies all the other components is a conventional roundtable structure, which serves as the focal point for discussions and collaborative planning. The desk area is equipped with a large screen and all the necessary information, including printouts and informative posters enabling an offline experience, but with the ability for anybody to instantly show ideas and references or archival knowledge on screen. This enables participants to share their ideas and progress in real-time with all affordances of a digital archive, while leaving space for individual forms of knowledge transfer.

Figure 5

Zoning effects: the Area for sharing experiences and peer-learning

Note. A dedicated table was prepared to enable exploring digital results and to facilitate communal reflection.

Image Credit: Beril Ece Güler / InKüLe

The UploadStation.

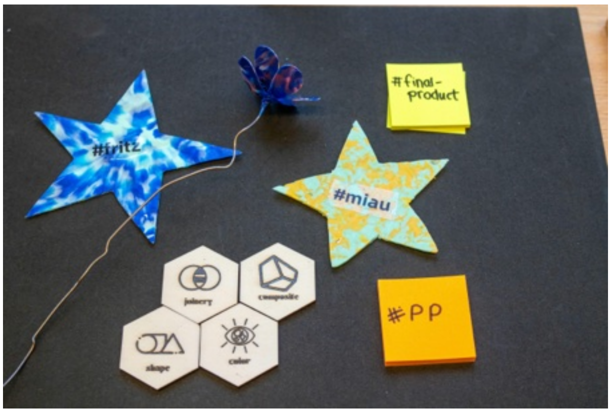
This is where the documentation takes place. It is a designated desk, slightly separated from the working area, yet close enough to cause as few obstructions to its use as possible. The UploadStation has an assortment of paper, markers, and pens, such that any concept can quickly be sketched out. To make the process even quicker, also the sketching or tagging is optional: the fastest way to convey an idea is by moving any pre-printed marker into the frame of the camera along with the research object.

A marker, in this context is a plate or chip, where a symbol is associated with a concept. The concept is written out along the symbol. A marker is not necessary at all, it is only a convenience feature to convey areas of import in the Upload without having to write. It also has the additional benefit of making a preselected set of concepts more likely to be used as documentary descriptors, essentially *nudging* participants to have similar structure in uploading. Three marker examples are visible in Figure 6: a wooden chip version, a plastic ID-Marker and tags on notepaper.

3.3.1. Areas and Stations

Figure 6

Three Different Mechanisms of conveying concepts in an upload



Note. *Image Credit: Photo by the author.*

The markers were tested in multiple iterations. The version using symbols depend on template matching, meaning the marker is defined by its specific (edge) shape. This has multiple reasons:

1. It is very fast: scanning a 4k image for the presence of over 30 markers takes less than 120 ms.
2. As long as the shape is distinct[9], the markers and their associated meaning are arbitrary.

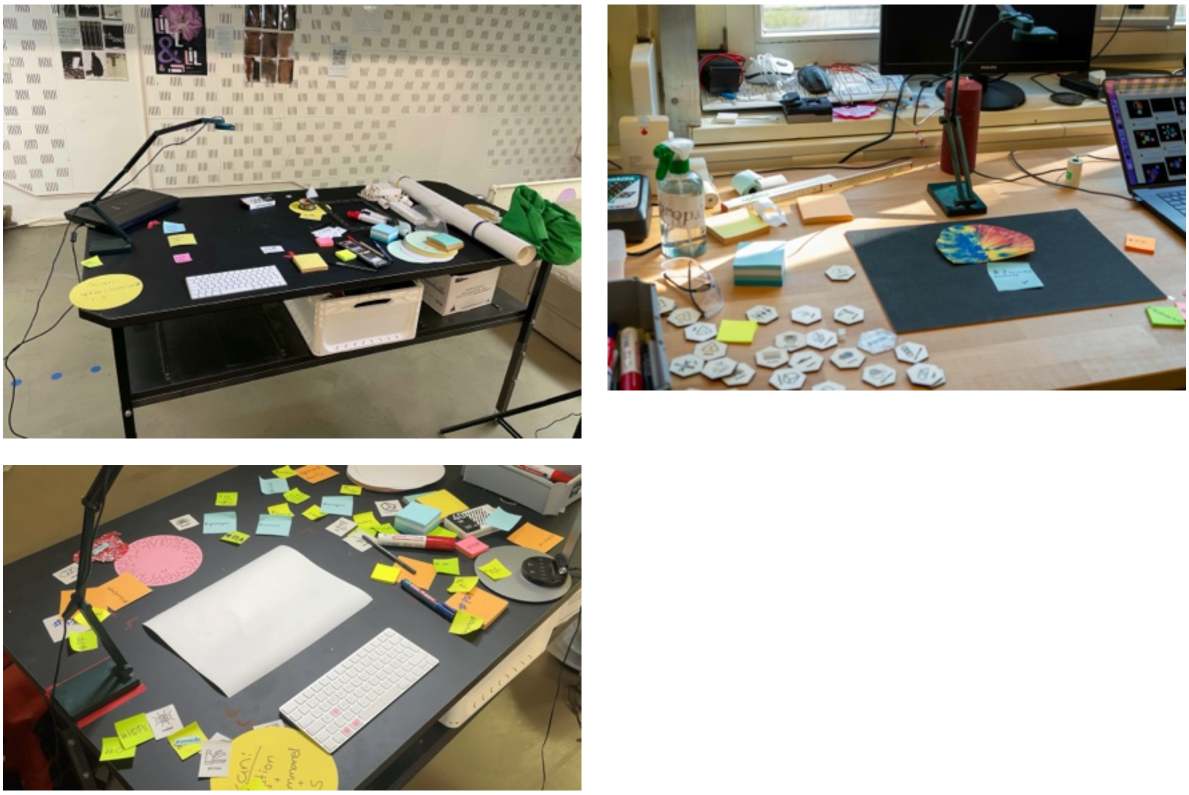
New markers can be introduced effortlessly and redefining their meaning is as easy as renaming a file.

I also tried laser-cut wooden chips as markers; sadly, the contrast was not strong enough to get reliably picked up. This was fixed for the second workshop iteration by hand-painting the laser-cut markers, which finally yielded the desired results while giving an optimized haptic experience.

[9]Hidden in there is also the biggest flaw of this architecture, only discovered in the process of the workshop: All recycling logos have the same overall shape, only distinct by the number in the middle. Using the recycling logo several times as a marker proved unreliable. In a real-world scenario with changing light conditions and people bumping into cameras, changing focus, etc., some markers had to be retired, as their shapes were too similar to each other.

Figure 7

The UploadStation in use, showcasing the Machine Archivist.



Note. An illustration of the upload process. As camera, a modified document camera was used, which allowed capturinge of high-quality images and videos directly from a hotkey on the prepared keyboard. The UploadStation was used to upload these media files into the archive system. Everything after activating the hotkeys was done automatically by the system. [Image location in the archive](#) *Image Credit: Photos by the author.*

The UploadStation denotes only the physical area of interaction with the participants. All of the software-back-end taking place here are discussed in Section 3.4.

As visible in Figure 7, several options of pen and paper are provided, next to a marked-out area for taking pictures. Any marker placed under the camera will get referenced in the upload. A simple shortcut on the keyboard triggers the process, along with a generated preview in the desk area.

An example result can be observed in Figure 8 and Figure 9.

3.3.1. Areas and Stations

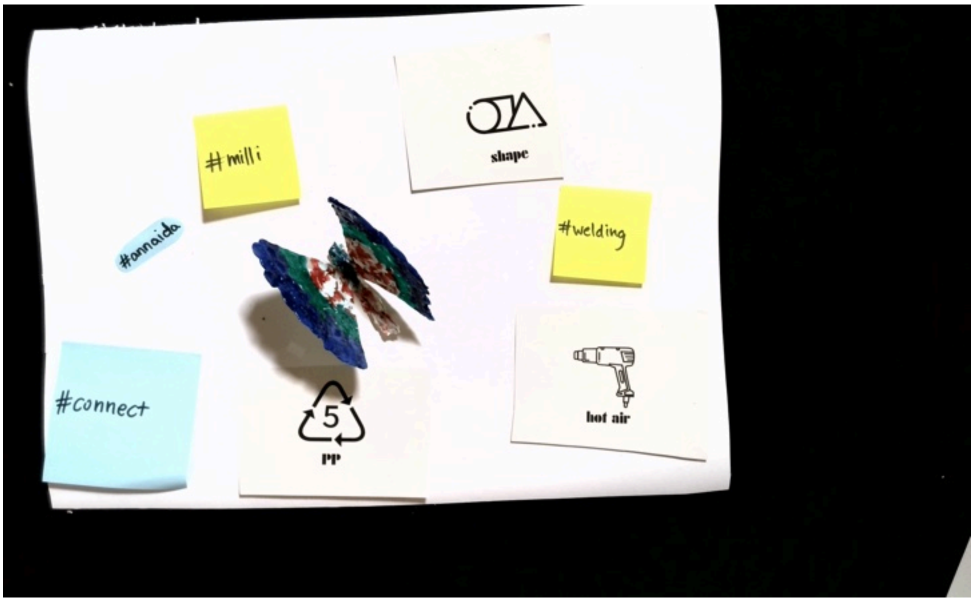
Figure 8

An ID Marker example after upload.

Note. Here, the general structure for the archival uploads is already present: the created object, in this case an ID Marker made from a pressed PP sheet. It is surrounded by various qualifiers, either depicted as pictograms or written notes. The image is linked to the archive page, where it can be accessed and further explored. Image location in the archive *Image Credit: Photo by the author.*

Figure 9

A research upload showing gathered knowledge on welding plastic plates.



Note. Another example from the initial research results is the utilization of the hashtag function. This enables the creation of novel categories within the knowledge graph, thereby circumventing the initial constraint imposed on limited classes. Image location in the archive *Image Credit: Photo by the author.*

A deeper look into the internal processing of the images and the markers will be laid out in Figure 15.

After looking at the areas aiding in reflective and discussion states, now follows the layout for the explorative and practical part.

3.3.2. Machines

In this section, I provide a brief overview of the machines selected for the workflow, highlighting their specific advantages and disadvantages. I will also elaborate on the deliberations made in selecting and arranging these machines.

Shredder.

The Precious Plastic Shredder is a versatile tool designed to efficiently break down plastic waste into small, manageable flakes, making it easier to process and recycle into new materials. Its robust design accommodates a wide variety of plastic types, enabling the creation of sustainable, high-quality outputs from discarded items. By offering an accessible and affordable solution, the shredder empowers individuals and communities to actively engage in local recycling initiatives and foster circular economies.

Figure 10

The Homebuilt Shredder

Note. It combines the motor and controls of a standard garden variety wood chipper, chosen because its motor is strong and geared for high torque and low speed, with a robust cutting mechanism that can handle tough materials like PET bottles, PVC pipes, and more. The shredder's design allows it to be easily disassembled for cleaning and maintenance, ensuring its continued performance over time. The shredder-box is manufactured according to specs from Precious Plastic (2025), consisting of watercut steel and threaded rods, welded for strength. *Image Credit: Photo by the author.*

A shredder, in this configuration is a welcome aesthetic tool, in such that it gives us control over the particle size used as inputs for the plate-pressing process, enabling greater color precision, but it is more or less optional, since most of the plastic pieces a 2kw shredder can manage are able to be melted whole in the heat-presses. Its biggest use turned out to be an organizational one, since storing granulate is far easier and more space-efficient than storing filament or failed prints.

During the first workshop, it was used to shred a number of PLA support structures, in the second workshop is was not used at all.

The MaterialStation.

For all of the shredded material, there needs to be a way to store them, keep them sorted and clean, yet portable. Herein lies a delicate balance, since it will become infeasible very quickly having several colors from every type of material on hand. The material station is made from an IKEA serving kart and several restaurant grade steel containers on aluminum rails. This Configuration attempts to solve the storage issue in a compact, versatile and portable form factor. One moot point here is the labelling. For later iterations it would be convenient to have material type and color on a given container labeled in a reusable fashion. In the current, more prototypical fashion, it was nevertheless quite usable and comfortably fits more color variations than really needed for initial experimentation. It was able to store almost 20kg of assorted plastics, which far exceeded the needs of both workshops together. Arguably, the overall objective of flexible and efficient storage is met in this iteration and it hopefully serves in many more upcoming formats.

Figure 11

The MaterialStation

Note. Image Credit: Photos by the author.

After participants had selected their materials and colors, they would continue to the heat station described in Section 3.3.2.3.

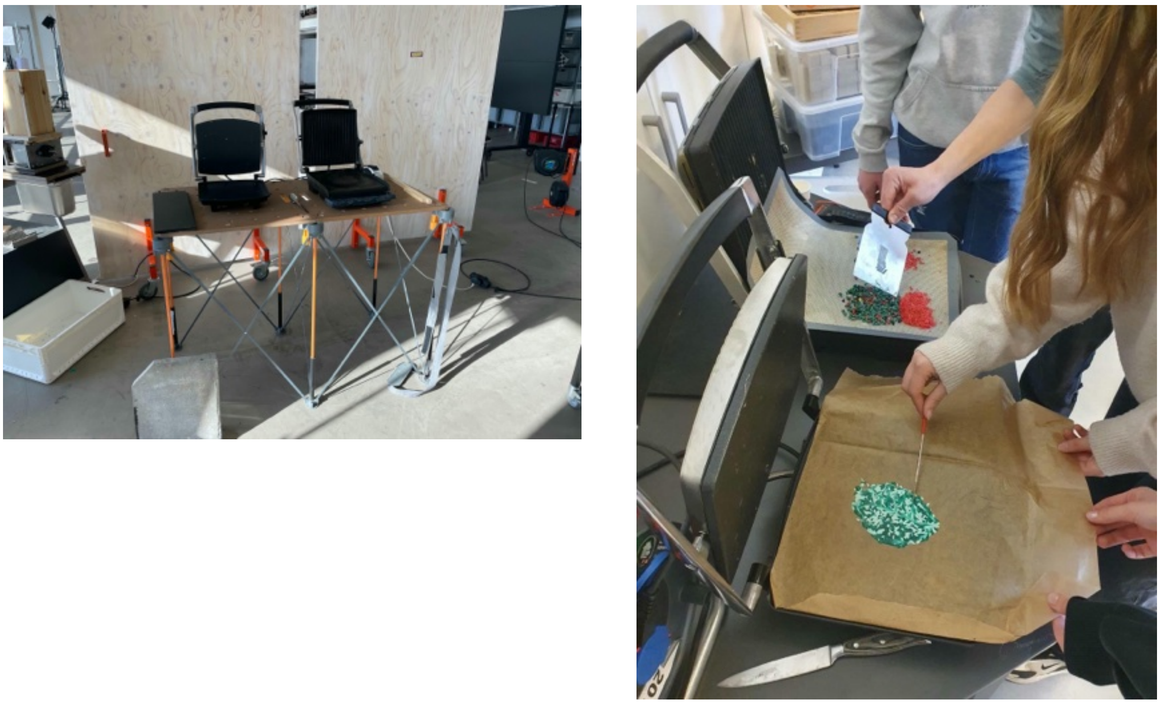
Hot Press.

In order to create sheet goods, some kind of flattening heat source is needed. After a bit of research into cost-effective solutions, a ribless sandwich maker was used. In a pinch, a clothes-iron already works and as a more dedicated tooling heat-transfer presses used in textile printing yield great results. For larger that 30 by 30 cm sheets, custom industrial tooling becomes necessary, since most plastics happen to be great thermal insulators and heating can require excessive amounts of energy.

The solution at hand is limited to sheets the size of A4 paper, which proved an excellent middle ground of speed, usability and quality of results. Some modification might be necessary to ensure level sheets, since the pressure is only applied along the center axis, but for the first tests, this proved sufficient. If you happen to hold a physical copy of this work, you can judge the quality yourself, as the outer shell was produced with the tooling described. The Sandwich Makers are comfortably reaching 250°C, which is enough for all plastics used in the context of the thesis. Making surfaces non-stick is the name of the game , and common baking silicone proved as usable as baking paper or the ceramic coating of the sandwich maker itself. Having multiple working options enabled interesting experiments manipulating the surface quiality to a desired effect. Some optimization was achieved here by adding an oven to keep plastic warm and enable larger batch sizes and faster processing (see Figure 1.

Figure 12

The Heat Press Area



Note. Image Credit: Photos by the author.

CNC Station.

Thanks to the support of InKüLe, there are two Shaper origins available. These are specialized CNC machines, in that they allow for handheld operation, making them more than digital fabrication tools. They require a vector image to work, which can be created from multiple sources. One of particular interest here is via Shaper Trace, a workflow where it is possible to digitize any object or sketch via taking a photo of it with a specially marked reference frame.

Figure 13

The CNC Cutting Station

Note. The Shaper Origin combining digital and analogue fabrication techniques. It is of special interest in education contexts, because various self-checks and correction features make usage much more accessible than a traditional, purely computer-controlled CNC-Machine.

Image Credit: Left: Aron Petau, Right: Beril Ece Güler / InKüLe

The Post-processing Area.

For the purposes of the workshop, any process happening up until this point was structurally constrained on a unified scaffolding for all participants. Design and Research decisions could be taken, but it was generally suggested to take the provided material in granulate form, press it into plates and carve some form out of the plate either using hand-tools or the CNC (Section 3.3.2.4).

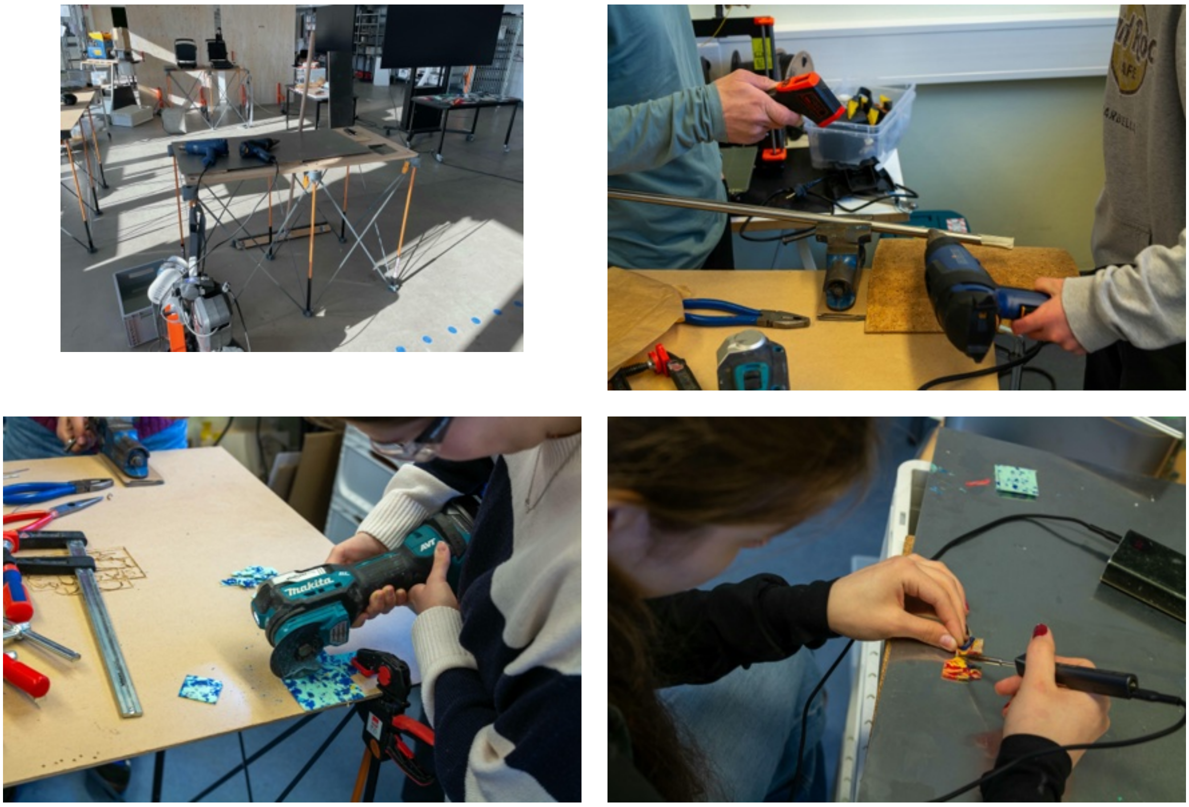
3.3.2. Machines

This station then provides an explosion of opportunities, where one is forced structurally to already have some preconception of a final object in mind. Post-processing then denotes any work done to an object after it has been pressed into a plate and carved. I will now lay out some prominent options for post-processing. It would not serve the thesis purpose to make the list exhaustive here, but instead the post-processing is to be understood as an open category, inviting research not only on a design- and material level, but also to gather new processual knowledge.

One example for that is a research group in the workshop examining whether melted plastic can be treated using a glass-blowing process. The result of that can be seen in Figure 31. Underneath, various other postprocessing methods are presented in Figure 14.

Figure 14

The Post-Processing Area



Note. In the post processing station various techniques were explored: one team explored the potential of making plastic roundstock material, by melting it in a pipe, relying on plastic shrinkage for extraction. Another team, exploring bending and folding, discovered that a multitool with a vibrating wood saw provides by far the cleanest straight cuts. Plastic soldering as a welding technique was universally well-liked for a number of bonds without any type of glue. *Image Credit: Photos by the author.*

The Postprocessing Area is only an umbrella term for several more specialized tools, some already visible in Figure 14. On a conceptual level, it is sufficient to acknowledge that the stations had a multitude tools and affordances to refine the plastic from one of the previous processes, from deburring edges, making surfaces shiny or matte, form-fitting components or welding. Some additional tools are discussed in Appendix C.2.

3.4. The Machine Archivist

Concluding the layout of the physical setup, now follow some considerations on the invisible parts of the UploadStation as introduced in Section 3.3.1.2, the Machine Archivist itself. In the following, I will provide an overview of the internal workings that are not directly visible to participants. While the constellation of algorithms is a blackbox in the context of the workshop, it nevertheless forms a crucial part of the infrastructure enabling the functioning of the workshop.

The Machine Archivist, in its simplest description, is a computer program. Programs are usually defined as having inputs, some data manipulation, and outputs.[10]. The inputs would be the markers, drawings, and objects placed on the photos, with the output being a preformed public archive in the form of several web pages, browseable as a semantically connected network.

The Machine Archivist can parse images, extract any text present, identify markers within the frame, utilize large language models for content description and text parsing, compile an archival entry incorporating all the collected information, and generate links to any entry with similar links. It then compiles all text and processed images into website-compatible HTML-code and deploys automatically to a public website.

The concrete and complete progam collection used in the workshop is available online, see Appendix E.4.

The design guideline for the Machine Archivist was to be as minimally invasive as possible. It should not require a computer screen and should not require typing out findings. Paper as a medium was preferred, as it leaves a level of stylistic finesse not present in typed-out words. Some medium or technology will always be needed to facilitate knowledge-sharing, and paper is strikes a perfect balance in enabling, yet not restricting. This takes the idea that interface design has to be human-centered and as enabling as possible from Norman (2013). Being able to use ordinary sketches and quick words on ordinary paper, which can then be scanned in a non-intrusive fashion hopes to engage all participants and introduce as little technological barriers as possible.

Even in contemporary, highly technologically advanced waste centers, a notebook remains the primary tool for classification. This highlights the inherent technological limitations of recycling as a large-scale industrial endeavor. On the other hand, it

[10]More accurately, but more abstract than needed, a program is a set of instructions that can be executed on a Turing-Machine, here is a modernized 5-Tuple definition going back to Alan Turing's : $T = (Q, \Sigma, \Gamma, \delta, q_0)$, where Q is a set of states, Σ an input alphabet, Γ a tape alphabet, δ a transition function, and q_0 the start state, together yielding a result, the output.

underscores the effectiveness of documentation and tracing as powerful tools for preserving and generating value in objects (Laser, 2020).

The Machine Archivist is born to capture a host of processes that typically get lost in the design and making process. It is designed to minimize interruptions within the creative workflow. As design constraints, the following principles were established:

- The device is designed to be used without sitting down.
- A single “start” interaction is sufficient for operation.
- The device is content-agnostic, capturing any object held within the camera’s frame.
- The device is as minimally prescriptive as possible, allowing users to disregard instructions and “hack” the archive for creative purposes.

Currently, the archive operates using a configuration file (.config), allowing the administrator to set various settings and select between different approaches. This includes defining the camera to be used, and in a Mac environment, enabling mobile archiving via the Continuum camera. Furthermore, additional optional analysis tools can be incorporated into the pipeline, contingent upon the specific requirements of the workshop.

The archive is fully reachable under archive.petau.net. For a code summary as a graph, please refer to Figure 15.

The Machine Archivist is, through its functions and design, delivering a value-creation process, where knowledge is pre-structured for further public use. This process is further described in the following.

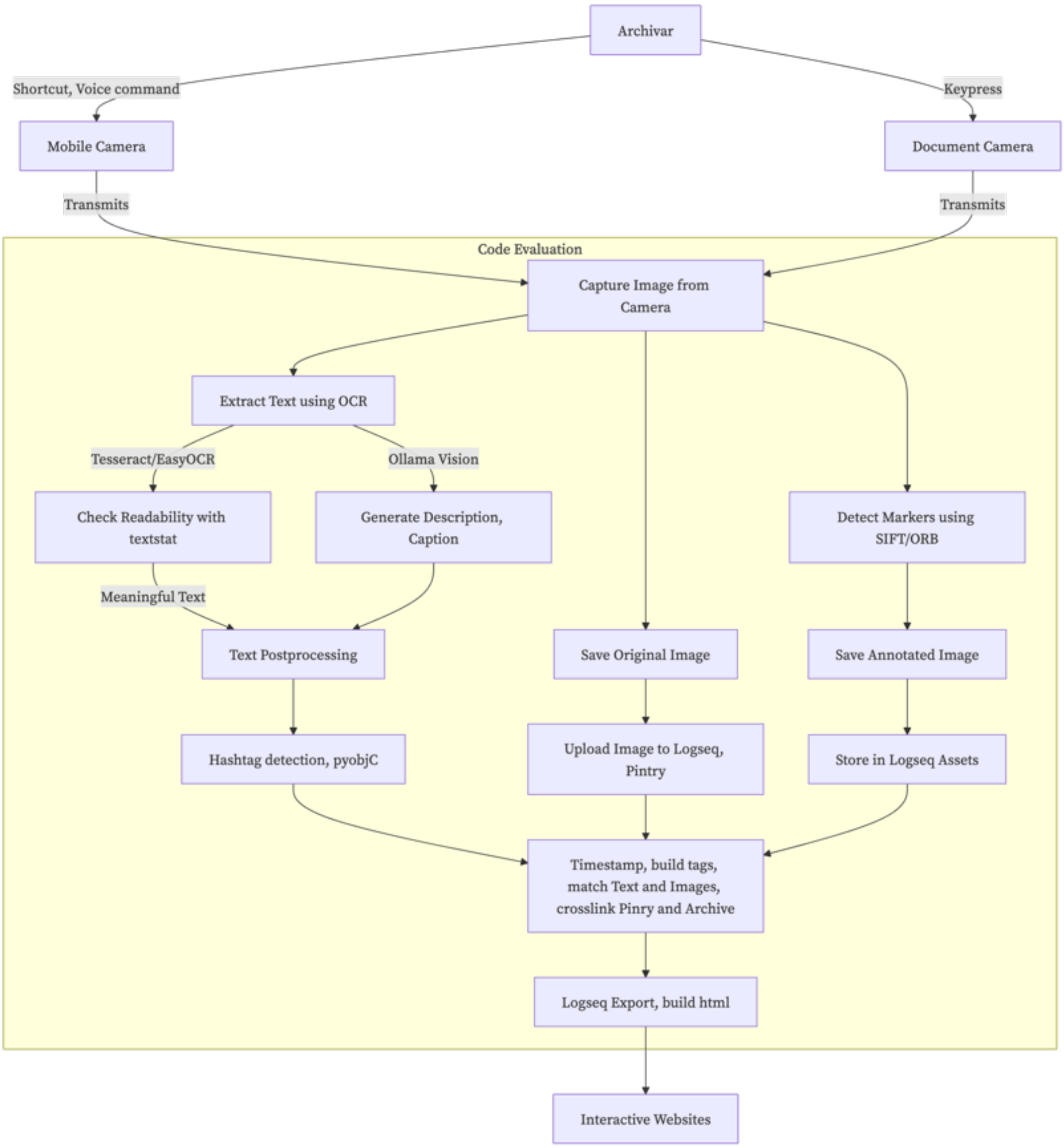
3.4.1. Back-end Description

To get a deeper understanding of the software architecture used, a visualization providing an overview is available at Figure 15. Importantly, everything happening the *Code Evaluation* section is fully automated and requires no further user input, as per the design intention laid out earlier.

3.4.1. Back-end Description

Figure 15

The archive internal workflow



Note. The graph shows a simplified overview of the internal processes happening. Each box has a few library options that can be set by an administrator. The entire code execution then happens with the set variables without further user interaction. A 1-click interface is created. *Image Credit: Graph by the author.*

Some current restrictions of the back-end are that using the smartphone as a camera depends on Apple's Continuum-Camera feature, meaning it is hardware-specific and bound to all devices using the same WiFi. With this concern in mind, also the proprietary software being used in the current iteration can easily be substituted, although with performance losses. The website build for archive.petau.net happens locally but is still hosted at github.com, a server located in the USA. pinry.petau.net is fully running on private infrastructure in Germany. From the server location, potential data privacy concerns arise, with a fully local setup being better suited for German consumer data rights laws (DSGVO)[11]. In order to mitigate these concerns, disabling internet connectivity completely is possible, with the archive still being available locally.

Enabling and disabling each module is sufficient through a Command Line Interface. However, a graphical user interface for administrators may be necessary for further adoption. All computing steps except hosting occur locally on a single machine. A portable setup without internet connection is possible, resulting in temporary uploads to local sites, which may not fully fulfill their function as permanent archives. The image capturing and analyzing pipeline comprises approximately 1,000 lines of code and consistently processes a 4K image in less than one second. If LLMs are enabled, the upload time increases to approximately one minute. This leaves a lot of room for speed- and frontend-optimizations but already proved stable and usable in the semi-supervised workshop environment.

A more detailed discussion of the back-end code architecture is to be found in Appendix D. While a complete discussion is out of the scope of this work, a fully commented version is available online, see Figure 10 in Appendix E.4.

[11] https://dsgvo-gesetz.de

3.4.1. Back-end Description

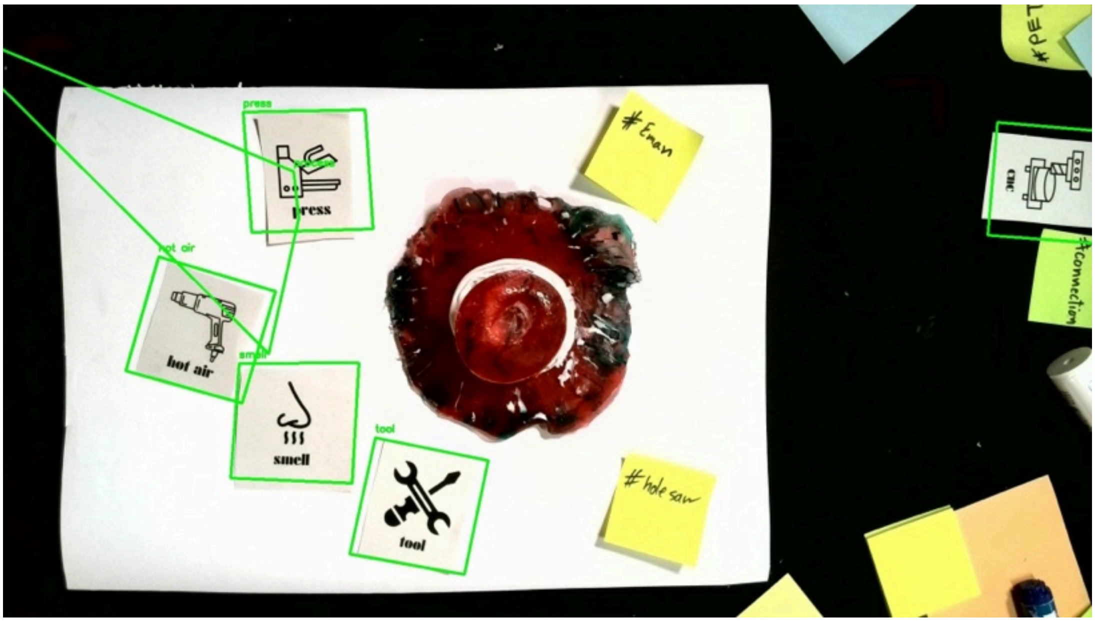
Figure 16

Template matching in a mobile upload

Note. A view with one of the internal template matching algorithms visible as overlay. It first detects edges and salient keypoints, usually areas of high contrast, then compares those against a set of known images, the markers. The visible circles were created using the ORB algorithm via openCV (OpenCV Contributors, 2012). *Image Credit: Photo by the author.*

Figure 17

Some detected templates



Note. In this image, the detected templates are visualized with bounding boxes as overlay. As visible, the process is not completely reliable (see the false positive template drawn), but it can handle rotation, partly occluded markers and slight perspectival shifts. Several optimizing customizations were implemented, like assuming all markers are square and have a certain size, which helps discarding false positives. *Image Credit: Photo by the author.*

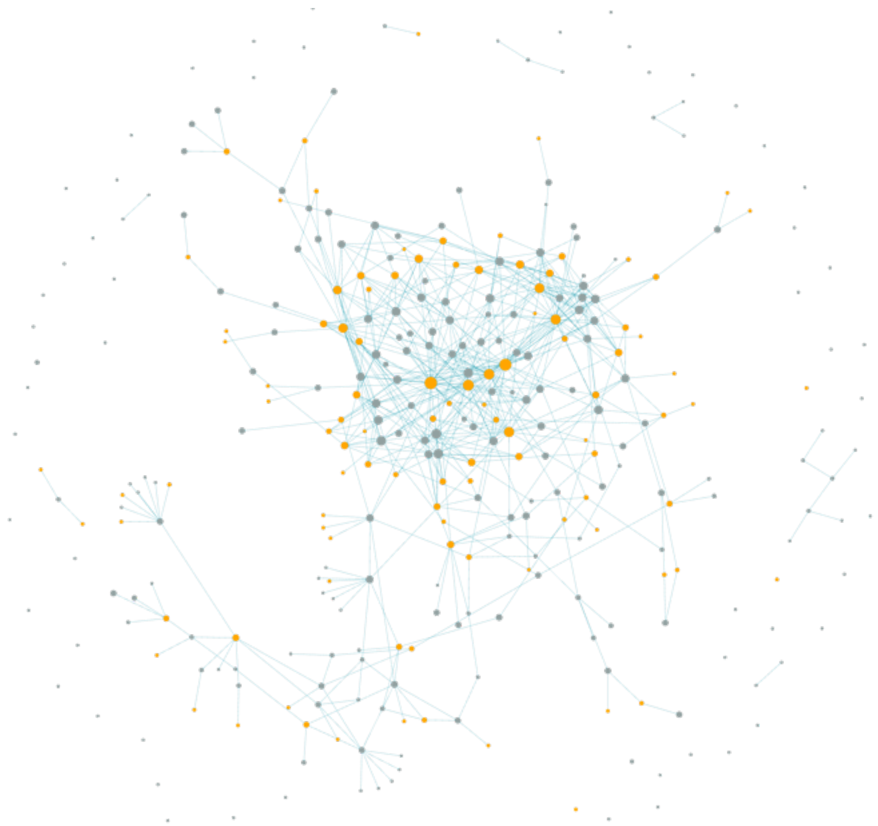
3.4.2. Presentation of the archive

An archive becomes only an archive once it is re-visitable and can be browsed by users. The UploadStation, as part of the workshop, only serves in an additive capacity. To enable further interaction, connecting dots and synthesizing knowledge from it, it needs to be available publicly. This was realized through a public website. The website serves each upload as a single site, timestamped and with the extracted tags. One feature of the webpage is a view of the densely connected graph visible in Figure 18.

3.4.2. Presentation of the archive

Figure 18

The connected graph



Note. Each page is represented as a grey node and each tag is represented in yellow. A nodes size depends on the amount of references it has. The entire graph is interactive and can be used to traverse the network of uploads. It also holds all information presented during the workshop. The image is produced through archive.petau.net/#/graph.

Several frameworks and solutions for public display were tested, and the selected one is not yet optimal, a main flaw being that it prevents any data manipulation after the upload by the participants. Data can be added both manually through the host machine and in an automated fashion through the UploadStation (Section 3.3.1.2). The only way to edit data in the present version is through the host machine. Since editing by participants was a desired feature, but the chosen architecture prevents a non-technically involved solution, Pinry, the image-board (Bythewood et al., 2024) was added. It is only partially connected to the archive, through automated cross-linking URLs, permitting autonomous data creation including manipulation by the participants. Given that the project is Git-based[12], theoretically

[12]Find elaboration on that in Section 3.4.4.2

providing multiple host machines with editing access is feasible, although this aspect was not implemented within the scope of this work.

3.4.3. The Case for Markdown as persistent archive

For knowledge transfer and archiving, the digital is not always a net positive. Things get lost in the Internet, and ever-changing digital landscapes can be frustrating for researchers or historians looking to trace the origins of ideas. No data format has really persisted since the very first days of the Internet. Archiving and storage of Semantic Knowledge is a hard problem and gets harder through rapidly changing standards and platforms. Markdown, a lightweight markup language which is around since 2004, is one of very many proposals to store knowledge in a human-readable syntax in text files. It is platform-agnostic, resilient against private appropriation, efficient, and hopefully long-lasting. Markdown is widely adopted, open for architectures to build on top of, and not dogmatically enforced. Any archival system based around Markdown will be easy to store, to maintain, and simply future-proof (Gruber, 2004). I would argue that it is almost as transformative for the digital world as the email standard, as large services like Google Docs or GitHub fully support it, and that is discounting its prominent use in AI: all of the large language models employed here (see Section 3.4.4.6) are able to parse and output Markdown syntax perfectly.

3.4.4. Software used for the archival process

It is not common to cite software in academic research; it usually only happens when the software is of special import to the project or the software itself is the object of research. The point of citations is to increase transparency over one's sources. As this is an artistic research, and the overall argument of connected and embedded knowledge is made, herein lies an attempt at increasing transparency over the work involved. Software, frameworks, and their affordances enable my work at least as much as an academic paper read. Therefore, a necessarily incomplete effort is made here to attribute utilized prior work.

Python. Python is my preferred programming language, enabling the realization of the Machine Archivist project. Provided by the Python Software Foundation (Rossum, 1991), Python is a widely adopted high-level language with extensive support and a comprehensive library ecosystem. All of the following software components can be controlled through Python, making it a sensible choice as architecture.

3.4.4. Software used for the archival process

Git. Git is a distributed version control system originally created by Torvalds (2005) that allows you to track changes to files over time. Git is widely utilized by developers for collaborative code development and project management. From a software perspective, Git serves as the de facto standard for project archives due to its ability to maintain predictable and deterministic behavior even in large collaborative environments. For the Machine Archivist, Git provides a deterministic storage and backup solution, potentially enabling archiving from multiple sources in parallel. It also facilitates a stable uploading mechanism through GitHub, an online hosting service based on Git.

Mermaid. Mermaid is an implementation of Diagrams-as-Code. The fundamental concept is that a diagram is formalized in a strict syntax that enables it to be fully described with human-readable text. It integrates seamlessly with Markdown. All schematics and diagrams presented in this work are generated using Mermaid (Sveidqvist & Contributors to Mermaid, 2014). The Concept of storing diagrams as text makes them editable after their generation and storage-efficient (in contrast to diagrams as images). Should the Machine Archivist be expanded in the future to recognize and extract drawn diagrams, a formalized syntax like mermaid would become necessary.

Logseq. Logseq is a knowledge management platform distributed by Logseq, Inc (2020). It enables the creation of non-linear relational notes and diagrams and is related in its concept to Wikipedia[13] or rather its Knowledge Graph, Wikidata. It is particularly useful for organizing thoughts and ideas in a visually appealing and intuitive manner. Logseq stores all content as markdown files and also enables linking and hierarcies between concepts, which is necessary to create a Knowledge Graph from text. It is chosen for the Machine Archivist because it has a public API, enabling automated control via Python.

openCV. openCV is a classic library for python, handling anything related to computer vision provided by OpenCV Contributors (2012). This tool is employed within the Machine Archivist project to manage image processing tasks, including template matching and edge detection.

Ollama. Ollama is a comprehensive language model handler and library developed by the Ollama Contributors et al. (2023). The API facilitates the local deployment of large

[13] (Wikipedia contributors & Wikimedia Foundation, 2001)

language models (LLMs). Ollama is employed for image description tasks within the Machine Archivist. Additionally, it was utilized in a collaborative creative process for writing the back-end of the Machine Archivist.

Within Ollama, several LLMs were employed for different tasks, such as:

- Performing OCR and Image description:
  - Llama3.2-vision by Meta AI (2024a)
  - The Vision Framework[14] by Apple Inc. (2017)
- Text and Code Completion:
  - Qwen2.5 by Yang et al. (2024)
  - LLama3.2 by Meta AI (2024b)
- Software Library choice and Coding Strategy Recommendations:
  - ChatGPT 3.5 published by OpenAI (2024)

ChatGPT was also employed as a discussion partner to assist in structuring the chapter-segmentation of the thesis itself. No unsupervised outputs were used. Please refer to Appendix B for further details.

Pinry.

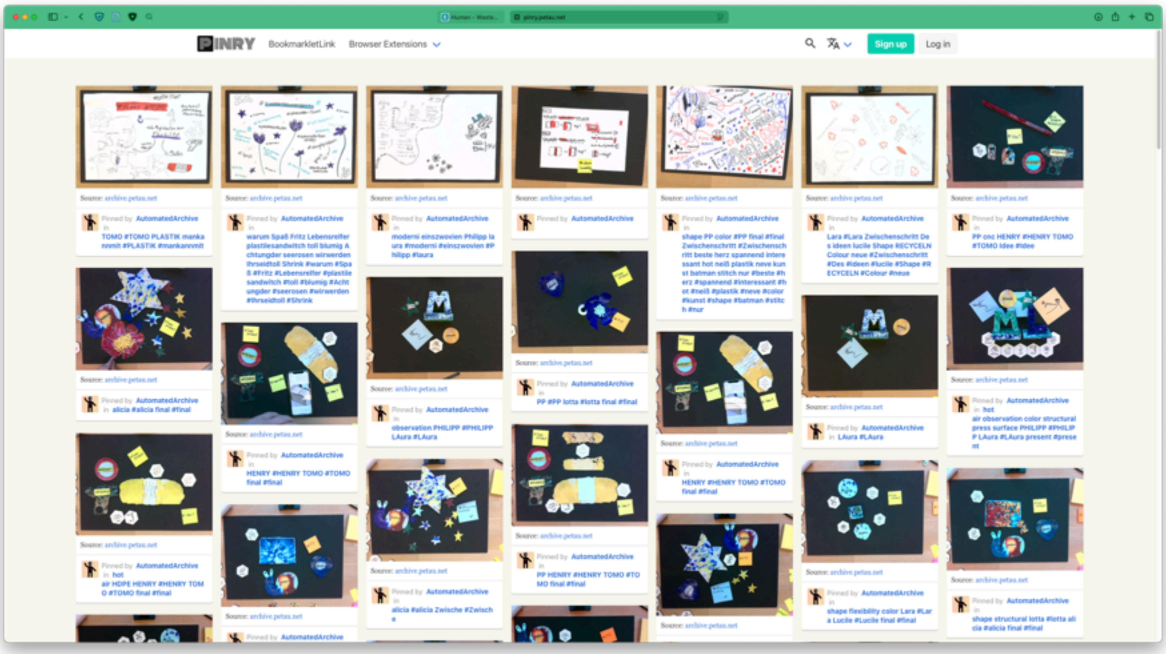
Pinry, created by Bythewood et al. (2024), is a tiling image board system for people who want to save, tag, and share images. It has an API controllable via python enabling the Machine Archivist to automatically upload all Photos associated with the detected tags. The tags can be used as filters, but also serve as visual clues to an image. For an example screenshot, see Figure 19. Consequently, it is inherently collaborative and functions as a supplementary resource to the Machine Archivist, offering a more comprehensive interface tailored specifically for image-focused users. Although it lacks the relational structure of a knowledge graph, it incorporates efficient upload navigation capabilities. It was used to realize pinry.petau.net.

[14] This is technically an entire developer framework, but it is closed source so it is assumed here to also be using LLMs internally.

3.4.4. Software used for the archival process

Figure 19

The Pinry Interface



Note. Image Credit: Screen captured by the author.

Algorithmic alternatives and observations.

For the Machine Archivist, a positive surprise was how well the last (of many) iterations of Optical Character Recognition (OCR) worked. OCR for printed text presents essentially a solved problem in computer vision and is being used in book digitization or PDF-standards since decades. Detecting handwritten characters is arguably much harder, due to the huge diversity of handwriting with only abstract common features. Here, the first deep neural networks promised much progress, but anybody who had to perform a reCaptcha on any webpage in recent years has to admit that reading scanned handwritten letters can still be tricky, not only for machines, even for humans.

Several algorithms, such as *tesseract* and *EasyOCR*, both available as python packages, worked well on the printed markers but were struggling with handwriting. Large language models already performed noticeably better, but were taking the upload sequence from 2 seconds to 2 minutes. They are implemented and can optionally be enabled to perform OCR. The solution that did the best in the end was utilizing the built-in Apple Vision framework using *pyobjC*. Essentially, these algorithms are Apple's proprietary methods for extracting handwriting and other text from Photos. This option is both fast (170ms) and the most reliable of all available choices. It is also capable of detecting QR codes, bar codes, and URLs. The present solution is hard to recommend since it is bound to specific hardware and proprietary,which is why it is optional in the software, but it enabled mostly flawless detection of hashtags. This made it possible for users to expand on the markers, transforming the previously closed class into a variable, ever-expanding one. All other solutions are left in place in the final version, giving a choice to all potential further users through the configuration file.

This concludes a deeper look into the algorithmic implementation of the Machine Archivist, the second pillar of the entire Workshop concept. The following section outlines the third pillar, all presented learning materials and the process-framework.

3.5. Workshop Overview

The first iteration of the workshop materialized as a two-day hands-on exploration of plastics, their properties, and transformation techniques. Taking place in the New Practice in Art and Technology studio environment[15], the articipants engaged in material studies, documentation, and reflection.

On the first day, the workshop began with introductions, where participants shared their backgrounds and expectations. A theoretical session followed, covering types of plastics, their identification, and recycling. Participants were then introduced to the machines used for material processing and documentation through the digital archive. Hands-on activities included creating ID markers, experimenting with material properties, and initial explorations of plastic manipulation techniques. The day concluded with a reflection session where participants shared their findings and outlined their plans for further experimentation.

The second day started with a recap and discussion of the previous day's activities. Participants engaged in extended free work time, allowing for deeper material studies. An interim check-in facilitated knowledge sharing before continuing explorations. The final phase of the workshop included group reflections, gallery walks showcasing work, and a plenary discussion on insights gained. The event concluded with participant feedback and

[15] https://www.newpractice.net/get-here

an evaluation of the workshop's impact. A more detailed documentation follows in Section 3.5.3, please also see additional materials in Appendix E.

3.5.1. The Participants

The first workshop was advertised by InKüLe, reaching students in all Faculties of the UdK Berlin. Project InKüLe[16], or *Innovationen für die künstlerische Lehre* is a research project concerned with digital and hybrid education research at the UdK Berlin and was elementary in supporting the workshop with funding, process support, and machines in the context of a peer-learning format described further in Appendix E.2.1.

9 students participated, along with members of InKüLe joining, taking part, and also facilitating and helping with the use of their machines. In the second iteration, 10 pupils from different classes in the 10th grade joined us.

Overall, this yields impressions and insights on the process from 19 people, all of whom were newly introduced to the press-making process and to the Machine Archivist. All of the documentation presented so far and in the following was created throughout the two workshop formats.

3.5.2. From Workshop to series

Within the context of my work in the *studio einszwovier*[17] at the Gabriele-von-Bülow Gymnasium, I was able to present a second iteration of the workshop. Over the course of three days, a workshop was conducted for a group of ten students aged 14 to 16. The workshop introduced the students to the principles of recycling and sustainable design, with a specific focus on the transformation of plastic waste into functional objects.

For the second workshop there was more time available and we were able to implement some minor changes based on initial learnings from the earlier workshop. While that makes them a little harder to evaluate side to side, all teaching content and tasks were identical. For a deeper revision of some structural differences and insights through that, please refer to Section 4.5.

For the remainder of this work, the results and observations of both workshops will be considered as one, interlacing participant findings and observations. As later visible in

[16] https://www.inkuele.de
[17] https://www.gvb-berlin.de/unterricht-plus/arbeitsgemeinschaften/maker-space-studio-einszwovier

Section 3.5.3.1, for the second iteration at studio einszwovier, the time available for free work was increased and the schedule of the second day was split in two.

3.5.3. Detailed Workshop Structure

Program.

Program Day 1	**Duration (180 Min)**
Who are we?	20 min
Theory Block	20 min
Machine Introduction	20 min
The Archive	10 min
Making your first ID Marker	20 min
Uploading first Post with ID Marker	10 min
The Infrastructure: what can we explore?	20 min
Research Group Formation	10 min
First Material Explorations	30 min
Reflection: what are findings and plans?	30 min
Clean Up	10 min

Program Day 2	**Duration (180 Min)**
Recap, Questions	10 min
Free Work time on Material Study	30 min / 45 min
Interim Check-In	15 min
Free Work time on Material Study	30 min / 45 min
Interim Check-In	15 min
Free Work time on Material Study	30 min / 45 min
Group Reflections: Final uploads	15 min
Plenary reflection with archive	20 min
Feedback on Workshop	20 min

The Workshop Schedule progressed from introductions to preformulated training tasks, ensuring all participants had the necessary knowledge to safely operate all machines. The training task here was to create a plastic chip with writing on it, serving as a marker, similarly to the concept markers introduced earlier in Section 3.3.1.2. These markers served a dual function: firstly, introducing the basic workflow of combining granulated material, pressing it to sheets, and then manipulating its shape through various means as laid out in Figure 4. Secondly, the produced markers with unique identifiers on them could later be added to the documenting process in the Machine Archivist to claim authorship for each individual piece of knowledge. With all uploads from a participant associated with a re-appearing marker, individual and group progress throughout the workshop could be traced. Through creating an ID-Marker, all participants completed an implicit basic practical training, after which research groups were formed, and all subsequent explorations were undertaken in groups, interlaced with regular Reflections in a plenum discussion, here named Check-In. In the following subsections, the processes are laid out in chronological order, first presenting learning materials, the marker creation, and afterwards, the group research with regular check-ins.

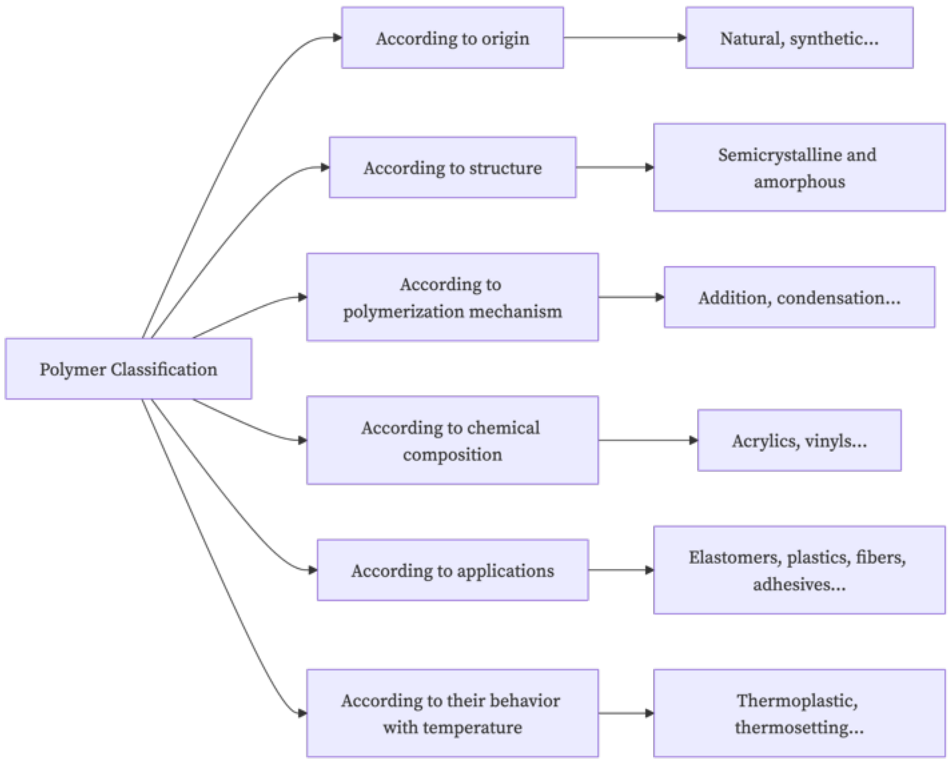
Polymer Identification.

Although the workshop was structured primarily on the practical research questions surrounding the materiality of plastics, it included the minimum viable knowledge on the plastics classes and labelling. Through this, no prior knowledge was necessary and the format opens up to anybody. The materials presented are taken mostly from other public information campaigns on sorting plastics, but the Precious Plastic Melbourne materials (Melbourne Precious Plastic et al., 2020) stand out as being prepared aptly specifically for laypersons in a sorting-plastic-as-workshop format.

As laid out in Section 1, plastics are a chemically heterogenous group and there are more subtypes than can be sensibly presented a limited timeframe. Figure 20 demonstrates some canonical scientific approaches of cataloguing plastics.

Figure 20

Different ways to classify polymers



Note. Polymers are a complex and large family. They can be classified along several dimensions. These are some common distinguishers used in research and industry (Oraon et al., 2025; Thangadurai, 2023). *Image Credit: Graph by the author.*

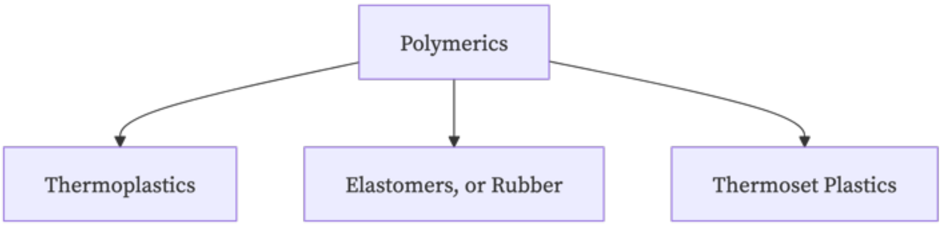
Plastics in the context of recycling are generally internationally grouped into seven subgroups[18], all of these subgroups were presented in the context of the workshop, with a special emphasis on the materials at hand in class: PP, PLA and HDPE. Find a selection of the teaching materials in Figure 21.

[18] for further specification, refer to Figure 21

3.5.3. Detailed Workshop Structure

Figure 21

The three subclasses of polymers



Note. Sometimes one finds elastomers excluded from this overview, as they are not necessarily a polymer. It is more of a functional definition: anything that stretches, is an elastomer. It can be of thermoplastic origin, then it is a thermoplastic elastomer (TPE), but it can be another class altogether, much like vegetables do scientifically speaking not really exist (Katz, 1998; Precious Plastic, 2025). *Image Credit: Graph by the author.*

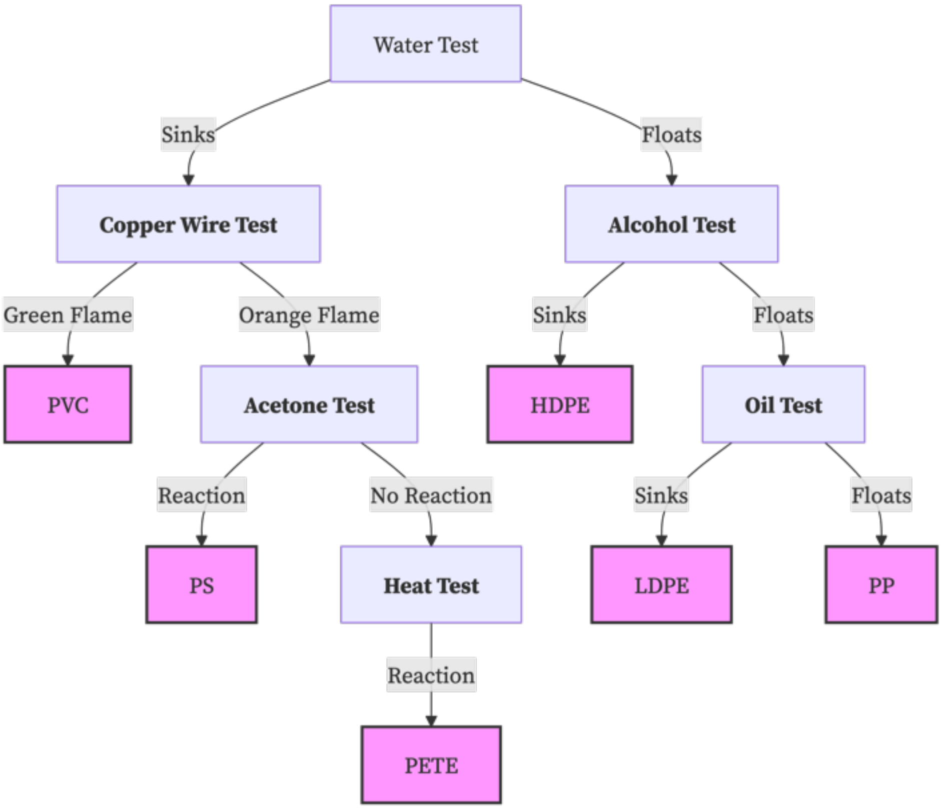
For the entire practical part labeled materials were provided in the MaterialStation (see Figure 11). Nevertheless, participants were encouraged to practice the *scavenging gaze* and bring materials of their own. To further facilitate their ability to identify and work with found and unidentified plastics, several strategies of identifying common plastics were presented. In a practical context, identification through visual cues is sensible and gives a rough idea. An overview table by precious plastic was used here, visible in Appendix E.1. Another strategy advised was a series of density tests, refer to Figure 22.

For toxicity information and further information it was referred to Bernau (2023), presenting a good overview over average decomposition times and leachates of different materials. On top of information as harm prevention, Masks and other PPE was provided, along with proper ventilation.

For the purposes of the workshop, I had prepared a series of density tests; with water, alcohol and vegetable oil. Further teaching materials are visible in Appendix E.1.1. Another good reference was the Identification decision-tree proposed by Katz (1998), to be seen in Figure 22.

Figure 22

A standard decision tree for identifying common polymer classes.



Note. Polymer Identification is generally a hard problem, since a pure visual inspection often does not suffice and multitudes of additives change nearly all testable variables. State of the art is currently near infrared spectroscopy (NIR), which is cost-prohibitive[19]. On a surface level, for artistic purposes, a few simple density tests are sufficient. This is a decision tree that found its way into many american basic chemistry classrooms (Katz, 1998). *Image Credit: Graph by the author.*

After all participants were equipped with enactable knowledge on harm prevention and personal safety, and further kitted out with the means to identify unknown materials, the machine introduction and practical training task of making a simple marker was given. Throughout all practical parts, demos and explanations were given as requested, implementing a student-led, on-demand learning environment.

First practical steps: Making Markers.

[19]This 3,600 Eur NIR scanner (plasticpreneur.com/psmk2plasticscanner) is one of the cheapest available and NIR in general fails to identify any black plastics.

3.5.3. Detailed Workshop Structure

After the briefing on all theoretical and safety-considerations, the first task was to prepare a marker, several example results were already introduced in Section 3.3.1.2, the process is shown in Figure 23. This way, each participant can be uniquely traced in the archive and simultaneously gets a first guided hands-on feeling of the machines and the prepared workflow.

Figure 23

First Contact: making colorful plates used as identification markers

Note. The Participants used paper cups to aid in sizing their plates and could gather first-hand experience on the heat-fusing process evident in the color swirls

Image Credit: Beril Ece Güler / InKüLe

After making some form of sheet material on the Hot Presses described in Section 3.3.2.3, the first option introduced was to cut self-drawn shapes out with the CNC Machine discussed in Section 3.3.2.4. To prepare for that, a shape had to be drawn into a prepared template to be digitized and then cut. This process was used by some participants both in the creation of the markers and later, in the group-phase, see Figure 24.

Figure 24

Participants improvising, making tools not provided

Note. To cut with the CNC machine, some paper templates were prepared to enable free-hand drawing that could later be scanned in using a function called shaper trace. The group decided they wanted a set of rings cut from a single plate and tried out various analogue and digital methods to achieve the best shape.
Image Credit: Beril Ece Güler / InKüLe

As evident in the unclear separation of the theoretical part and the practical part throughout the workshop, the aforementioned interlaced structure of *action-reflection-adjustment* makes it impossible to demonstrate a piece of knowledge without also inviting practical exploration. Many of the theoretical topics were elaborated on in plenum discussion during the regular Check-ins. This effectively resulted in a student-driven learning environment, harvesting benefits of the laid out "infrastructure-only" workshop model.

Next, the research objectives and prompts given to the students before group formation are reproduced.

The Group Research.

The four research groups consisted of:

- **Color Patterns**
- **Connections and Welding**
- **Thermoforming**
- **Surfaces**

3.5.3. Detailed Workshop Structure

Presented in the following are the initial prompts for the participants, but they were instructed to take the opportunity and pursue their own interest in plastics. Despite that, all participants found an area of research they liked in there and were able to form small groups going into research. The research phase was completely free, leaving the peers to find solutions among themselves. Still, an initial prompt clearly helped forming first ideas. Guidance and machine tutoring was available on request.

Color Patterns.

Could we manipulate the color mixing process? Specifically, how can we combine colors? How can we layer them? Are there any techniques for twisting or folding the colors? Can we mix different materials? What is the impact of temperature on color? Can we overcook or undercook the plastic? Are there any methods to achieve transparency and translucency?

Connections and Welding.

What factors contribute to the strength of welds? Are there techniques for reinforcing welds to enhance their durability? Can welds be rendered invisible for aesthetic purposes? Are there methods for creating specific connectors? Are there alternative, non-welded joint techniques that can be employed for specific purposes? How can hinges be constructed using non-welding methods? Are there techniques for sewing plastic materials together?

Thermoforming.

Could we achieve slumping, which involves melting the material into a specific shape? Are there any techniques for imprinting or embossing details while the material is still hot? How can the material be bent? Are there any material differences that would affect these processes? What are the possibilities for elongation? Can the material be melted until it reaches a liquid state?

Surfaces.

What are methods for creating regular or irregular patterns? Can patterns be stamped? How about inlays? Plastic inserted into other materials? Other materials inserted into plastic? Inscriptions or engravings?

After presentation of the creative prompts, the participants were able to join self-formed groups, according to main research interest. All research topics were chosen, with some groups covering even more than a single area of research in the later phases. With that, group research started, where all participants were directed to autonomously choose when to take breaks and when to document findings.

As visible in Section 3.5.3.1, a structure was laid out that followed each Research phase with a plenary round at the desk area (see Section 3.3.1.1).

These served as a consistent platform for collective discussion of newly acquired findings and current issues. Additionally, they facilitated group finding and networking opportunities, assuming that necessary skills had already been acquired by other peers. Each plenary discussion concluded with a concise review of the uploaded archival results (please refer to Section 3.3.1.2). This approach enabled the discussion of particularly noteworthy attributes of each upload and the emerging establishment of a common archival language. A hybrid setup emerged, where the digital documentation was presented to quickly relate outcomes among each other, but the groups in parallel handing around the created objects themselves, enabling touching and closer inspection for the entire group.

3.5.3. Detailed Workshop Structure

Figure 25

Some results from the experiments

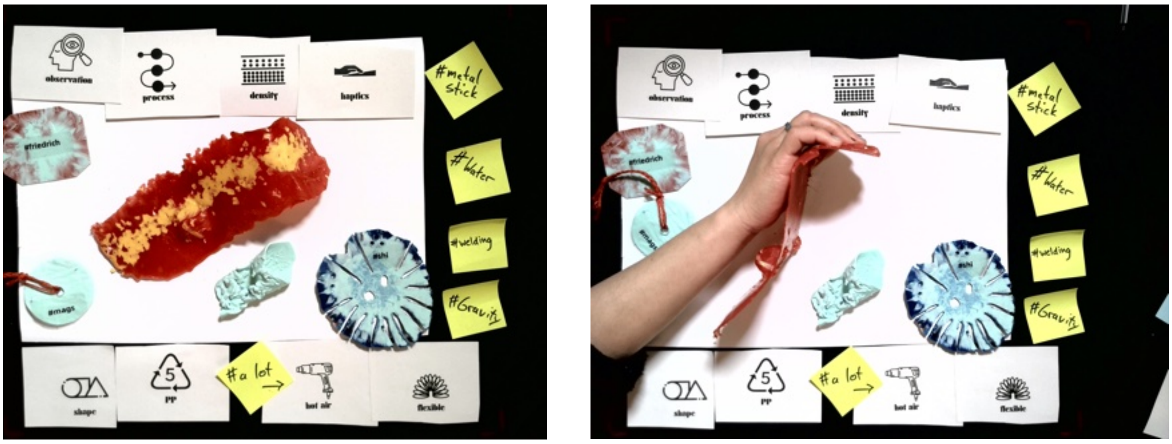
Note. In a few plenary sessions in between the research blocks, participants were asked to share some aspects of what they are currently exploring. Afterwards, finished experiments went on display here. *Image Credit: Photo by the author.*

In the following section, some documentation results and chosen participant workflows are presented, again drawing on outcomes of both workshops.

Impressions and Outcomes.

Figure 26

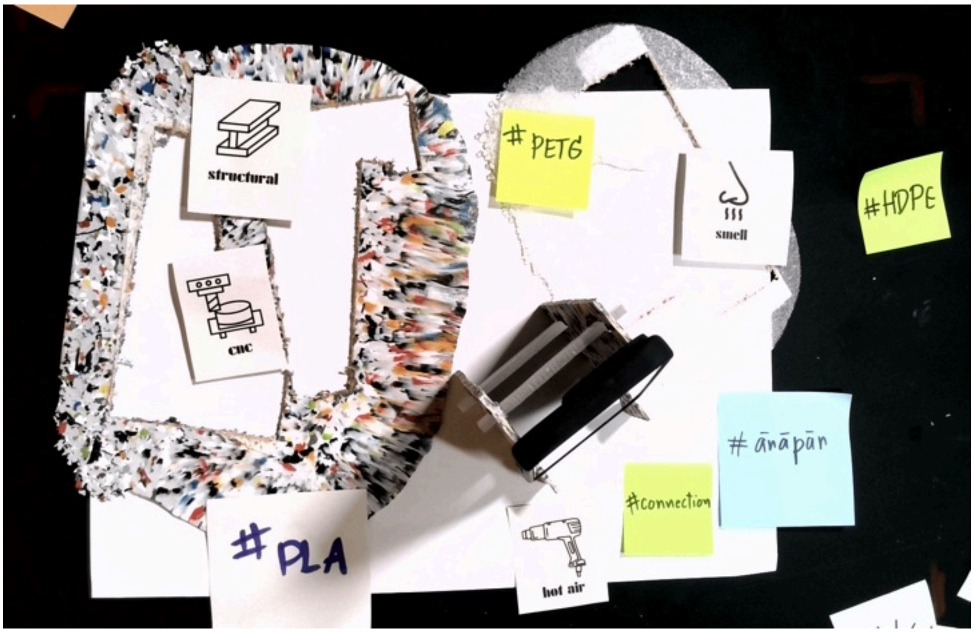
A result from a group researching thermoforming processes [*Image location in the archive*]() Image Credit: Photos by the author.



Note. Here, the Workshop participants explored ways to form a sheet of plastic to a hand shape. As can be deducted from the markers, that was done with a variety of tooling, notably trying out the heat-resistant silicone gloves, using them under the heat guns to obtain real forms of the hand.

Figure 27

A result from a group researching connections



Note. A participant used the CNC options to create a smartphone stand from multiple fabricated sheets of plastic. As seen in the documentation of it, PLA and PET were used here, two especially strong materials that delivered good results while being cut. The connections and joints are reminiscent of typical laser-cut connections.

Image location in the archive *Image Credit: Photo by the author.*

Figure 28

An eye mask created from Tupperware (PP)

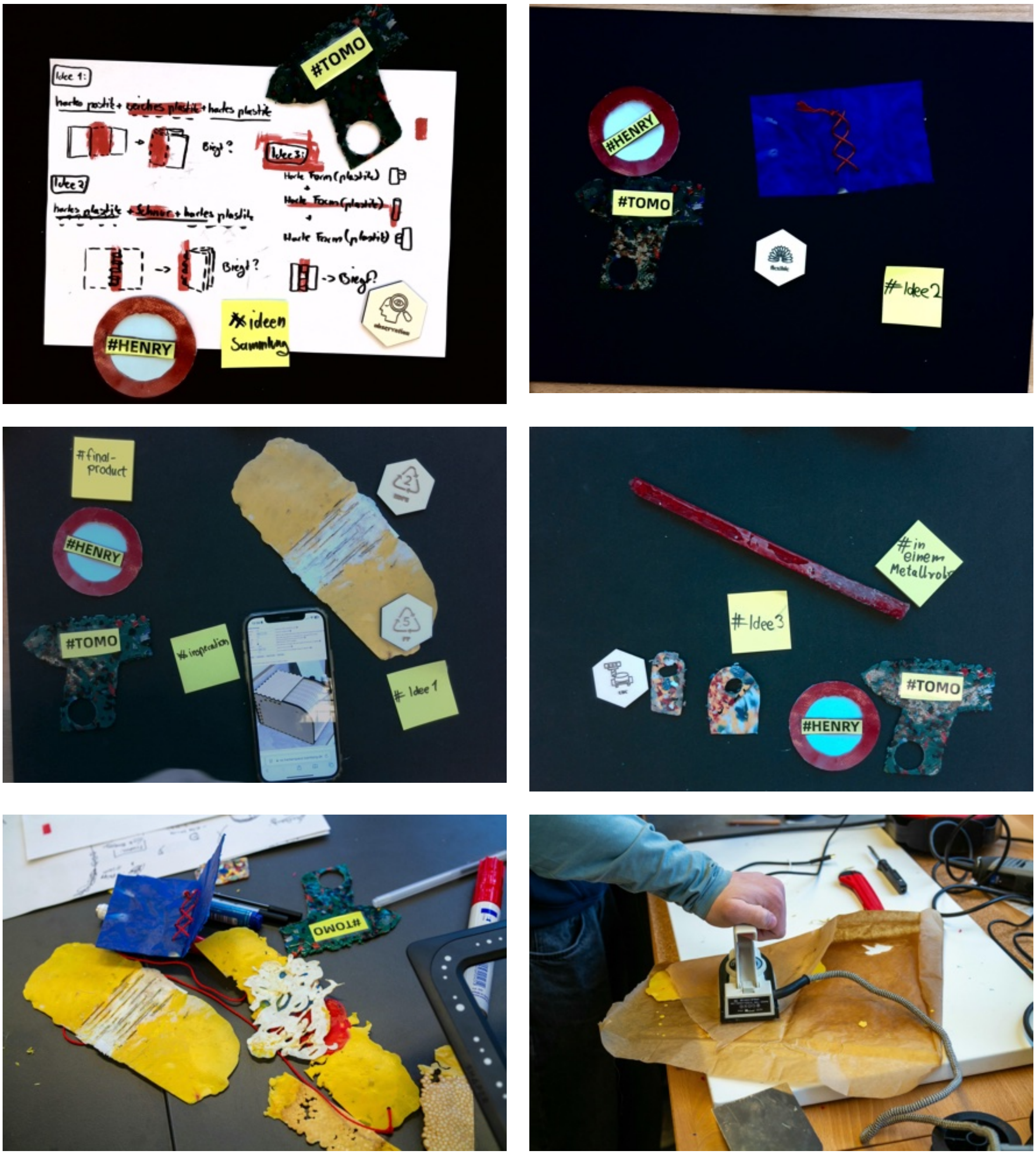
Note. Results from a group examining thermoforming properties of different plastic types. This piece was from some leftover foodstuffs box tops, that was then successfully identified using density testing methods supplied in the workshop and shaped with the heat gun and a water bath. Image location in the archive *Image Credit: Photo by the author.*

There were several instances where participants successfully broke down the boundaries proposed by the presented infrastructure: The Thermoforming group decided early on that they needed an efficient way to cool the pieces and created a water bath, which proved effective in "freezing" objects in their heated shape, which they would have lost if slowly melting.

Another instance was the trials with glass blowing, where the steel tubes provided were utilized as air-conductors. I had positioned the tubes there, anticipating that people might be interested in exploring the composite-material adherence techniques proposed earlier and welding steel or wood through compressive shrinkage of the plastics. However, that never materialized. Instead, the tubes were recognized as a tool, not only in that context but also for handling purposes. In many other instances, participants seemed to agree to the proposed research questions and adopted them.

Figure 29

Upload progression of group two at studio einszwovier



Note. This group was dealing with various mechanisms, bending plastics for repeating purposes. They acted planfully, sketching initial ideas and doing all material testing necessary to evaluate different techniques. *Image Credit: Photos by the author.*

For the outcomes of the other groups of the second iteration, please also see Appendix E.3.

For a full overview of the findings, please refer to pinry.petau.net and archive.petau.net. In the following section, the entire format and the here laid out working principles are reviewed in Section 4.

4. Evaluation

In this section, the focus will shift from the findings and results presented by the participants to the overall functioning of the workshop. I will present findings and observations to assess the extent to which the workshop successfully achieved its objectives.

To assess the research inquiries presented in Section 1.2, the feedback from the participants will be carefully examined, and the uploaded results in the archive will be analyzed. Additionally, I will present my own observations and highlight instances of autonomous re-valuation, moments where a shift away from *plastics-as-waste* can be observed.

Here listed are the evaluative divensions used to examine the success of the workshop series:

Participant Engagement. The assessment of success in this context entails evaluating participants' transformation of their perception of plastic waste. This transformation involves recognizing it as a resource rather than a disposable object. Active participation in discussions, hands-on exploration, and the capacity to identify and process various plastics are indicative of strong engagement. Participants should be able to operate machines, experiment with materials effectively, and document their findings in a digital archive. The evidence in support of this can be found at Section 4.1.

Knowledge, generation and transfer. In this analysis, I will evaluate whether the acquired knowledge was effectively conveyed within the structures of the Archive. This assessment aims to demonstrate the feasibility of knowledge preservation through the documentation process. For further exploration, refer to Section 4.2.

Level of Collaboration. As another dimension, the collaborative aspects of the workshop will be examined. The workshop should foster teamwork, peer learning, and knowledge sharing. A supportive environment and communal use of infrastructure has been shown earlier to be essential in meaning-making processes. Assessing the overall level of collaboration can provide evidence of whether the scaffolding infrastructure was in place and whether a Liminal Zone was achieved, as previously collaboration was carved out as a central precondition for the emergence of shared knowledge andlanguages. The evaluation of this takes place in Section 4.3.

Participant Feedback. Ultimately, the highest measure of success is the evaluation of the participants of a specific format. The Feedback also serves as an important source of validation for the aforementioned categories. Any insights that transcend these categories will be considered here, hopefully capturing concerns that could have been missed in the previous observations. For more information, please refer to Section 4.4.

Each of these four clusters are now examined more closely.

4.1. Overall Participant Engagement

The workshop introduced various plastic manipulation techniques, such as using a soldering iron for fusing, molding, layering, and bubble-forming. All the proposed research questions were utilized, and the participants self-organized into groups to set accents. The participants were actively engaged with the material throughout the research, and their interests were well-distributed. All quotes given in the following are taken from the Transcript of the Feedback voiced by participants at the end of each workshop, printed in full in Appendix E.2.2.

Figure 30

The thermoforming group collaborating in experimental setups.

Note. Experientially, participant groups developed their own strategies with predetermined goals. In this experiment, they explored the potential of using a non-pressurized mold for shaping purposes. They had the discretion to decide when to use heat protection and when to rely solely on their sensory accuracy. *Image Credit: Beril Ece Güler / InKüLe*

> "I tried molding a strip of plastic onto a bottle, but it just stuck down on both sides — it was just nice to play around and try out different things."

During the second workshop, the structure was even more relaxed and everyone was encouraged to take breaks at their discretion. This led to far fewer breaks than initially planned, indicating high engagement. Since plastic fumes can pose a safety hazard, at any point, the working pace was self-determined and breaks were self-guided. Participants appreciated this work setup and often continued investigating when I took a break.

A combined total of almost 250 uploads made with the Machine Archivist also indicates heavy use of the archiving tools. Please see Appendix E.3 for a further selection of successful uploads.

"I also really enjoyed the documentation moments. When you're deep in the making process, you forget to reflect on the material. The documentation process gives you a little time to do that."

Both groups, students as well as pupils, took well to the semi-structured format of having self-governed working time interlaced with regular check-ins with the whole group. All groups took photos in each independent working session. It often proved difficult to start a plenary round, since each time someone was still deeply immersed in a specific task. Participants were only slowly adapting to abandoning a task to receive yet more input from other groups.

Based on the feedback and the engagement, partly already presented throughout Section 3 and the many instances students performed a task or used a tool for the first time, all participants arguably had individual learning experiences.

Next, it is to be established that some knowledge did successfully transfer. As such, the instances of student-teaching are the most interesting. In this context, moments of peer-teaching are to be examined as well as the archival uploads themselves, since their purpose is to transfer knowledge towards the future.

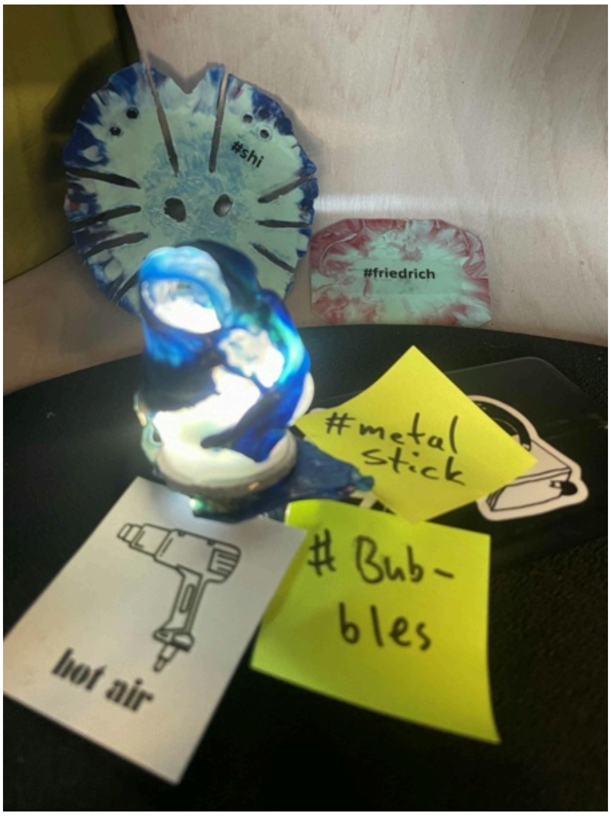
4.2. Success of Knowledge Transfer

In the first iteration, a little over 100 uploads were made in 2 days, forming a densely populated network as digital result of the workshop. The second iteration again contributed almost 100 uploads over 3 days. An extra camera was available for the participants there, which enabled even more documentational freedom and more perspectives.

In total, over 250 distinct photographs were captured by participants, each establishing a connection between attributory markers and one or more objects. This was also shown in Figure 18.

Figure 31

A mobile upload realized with shortcuts and Continuum camera



Note. An example showing the adaptability of the archival process. Initially, the rigidity provided by forcing participants to adhere to the prepared camera perspective from overhead provided a stable training ground for getting to know the system. Later on, the hashtag function was introduced to allow for more flexible categorization of the data. On top of that, the camera became mobile, enabling novel perspectives and a less disrupted research process. [Image location in the archive](). *Image Credit: Photo by the author*

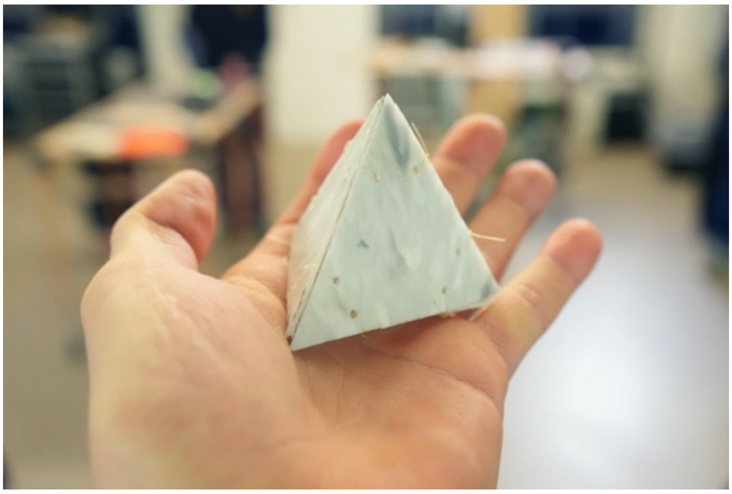
The Mobile Camera as a concept was heavily embraced by all participants. Before its implementation, they already frequently took photos with their own devices for personal documentation. The completely integrated mobile camera functioned too unstable for real group usage, worked only from a single device, and was at times not functional due to dependence on limited Wi-Fi bandwidth. The heavy usage of the dedicated camera (which was not able to immediately upload) indicated that a mobile solution was often preferred for documenting directly at the workplace. Despite the limited usability of the here presented prototypical solution, the larger scope of abilities of the camera proved welcome and was utilized by many participants. For further iterations using one or even multiple dedicated cameras in tandem with the now-implemented manual upload function of the Machine Archivist is preferred for stability and quality concerns.

Despite these considerations, the placement of a dedicated area for uploading proved useful too: documentation moments facilitated participants' reflection on their process and material interactions.

"Sometimes you get so deep into the making process, you forget that this is, you know, material, and then the documentation process gives you a little time to reflect." This indicates that the activity of documenting itself, selecting markers and actively thinking about which markers one wants to associate with the archival object, significantly contributed to a learning process, at least for some participants.

Figure 32

Plates connected with fishing line (nylon) to form 3D structures



Note. A Pyramid served as the first test in exploring whether sewing plastics is a feasible option for flexible hinges. Combining different materials and properties in a reversible way is a skill the industry lacks. Many recycling steps can majorly benefit from adjustments made in the design phase. Consider as example the multilayered Tetra Pak packaging material, in contrast to the yogurt packages where the paper packaging could be removed tool-free. *Image Credit: Beril Ece Güler / InKüLe*

4.3. Collaborative success

The collaborative nature of the workshop was highlighted during feedback as a strength, with individuals supporting each other's learning. The hands-on nature encouraged playful engagement and deepened understanding of recycling possibilities. Participants valued collaboration, learning new techniques from each other, and overcoming technical challenges together.

> "So many people helped me along the way, explaining how to use the drill, the printer, and stick it together—it was a real group effort."

There was also a strong sense of mutual support:

> "It was nice that whenever someone got stuck, there was always someone with a new idea."

Figure 33

A glimpse into a work-phase

Note. As visible here, the free and open arrangement encouraged spontaneous group teaching moments, not at all requiring any intervention. Material exploration could happen in groups or alone, sharing something on the spot or later in a check-in phase. *Image Credit: Beril Ece Güler / InKüLe*

Some participants expressed interest in continuing to explore plastic manipulation, potentially integrating found methodologies in their own artistic practices.

Collaboration as a methodology is hard to prove just with photos and the feedback of the participants themselves has to be evaluated for further clues on the success of methods.

The following section considers additional participant feedback, with a larger focus on their evaluation of the processes in place.

4.4. Evaluating Participants Feedback

The end of the workshop featured a 20-minute feedback round, serving to evaluate the didactic aspects of the workshop as a format and potentially collecting evidence on a perspectival shift that occurred during the workshop. The participants were asked to share a few insights and their views, especially regarding:

1. The open, explorative format,
2. the utility of the UploadStation,
3. their perspective on the role of plastics in society.

Some sketched out original feedback can be found in Figure 6. The Oral feedback is presented hereafter in selected format, the full transcript is accessible in Appendix E.2.2.

The shift from *plastic-as-waste*.

Participants expressed a shift in their view of plastic, recognizing its potential for creative reuse. Initially, some saw plastic as waste, but the workshop demonstrated its malleability and potential for transformation.

One participant noted:

> “It was really nice to experiment with everything, even though there was not like this one final product in the end.”

The ability to create new objects from discarded plastic was seen as an eye-opening experience.

> “We could easily see that new things can be made out of old things, and it’s like a very nice thing.”

Some participants now appreciate plastic in a new way, even stating: “I love plastic now after the workshop.”

The exploratory, research-based approach allowed participants to focus on process over final products.

> "I was thinking beforehand which product to make, but it was nice that we were not focusing on the final product, but more on the process and on finding out something."

Many found it liberating to experiment without pressure to create a finished item.

> "It was more for the sake of finding new things out and experimenting with something new instead of just trying to achieve something."

It appears that the underlying notion of a course as non-prescriptive was acknowledged and appreciated. The exploratory approach towards materiality adopted from the Bauhaus Vorkurs was well-received.

Impressions from the Workshop at studio einszwovier.

Transmatting the workshop from the initial context in a University of Arts to the context of a secondary school helps generate novel insights, because if successful, it demonstrates the adaptability of the methods. By changing the setting and target group for the workshop, the resilience of the epistemological concepts can be effectively tested, and I was able to iteratively implement first improvements, like eliminating unnecessary tooling.

All participant quotes provided here are translated from German, as the entirety of the second workshop was conducted in German. Overall, participants had a positive experience. They appreciated the freedom to explore materials and develop their own projects.

> "I thought the project was really great. I liked that we could research and develop our own projects."

The introduction to the materials was also well-received:

> "I found it helpful that we had a small introductory session to get to know the materials. That made the material and form exploration easier."

Many valued the open structure, which encouraged creativity, collaboration and the sense of ownership:

> "I'd keep it open like this, so people can work on their own ideas."

Participants discovered new tools and techniques, which they were interested in using again:

> "I learned about a lot of new tools. I could imagine coming here during breaks to work on my own projects."

A key takeaway was a shift in perspective on plastic—not just as a disposable material but as something with creative potential:

> "...I never thought of plastic as a creative material before.
>
> ...I only knew it in a recycling context, not for crafting or design.
>
> ...It reminds me a bit of fuse beads."

On the basis of this feedback, the workshop can be considered a success, providing hands-on experience, creative freedom, and new insights into materials. The balance between structured introduction and open-ended exploration was well-received. Participants expressed interest in future workshops, and the atmosphere was described as enjoyable and relaxed.

Reflections on the Workshop Structure.

Participants appreciated the open-ended nature, allowing for personal exploration.

> "I like that the workshop was two days because yesterday we explored things, and today we had an idea of what we wanted to make."

Some felt that rather than finding one essential product to make, the focus should remain on experimentation and material understanding.

> "Maybe we have so many products already, it's not about finding one new product to make."

The two-day format allowed for both exploration and more structured making on the second day.

Based on the feedback, we can see that the earlier-described shift in perspective, the initial seed of the *scavenger gaze,* was present. After the first day, several participants brought plastics from home to try out materials not provided. The first instances of scavenging were visible, also present in tool use. During the Format, there was only time to introduce the major machines, all the smaller tools, power tools as well as hand tools; even non-tools recognised as tools had to be discovered in a collective learning process, where the unavailability of an introduction often led to experimenting or instances of peer teaching.

4.5. How did the structure between workshops differ?

The second iteration of the workshop was attended by ten tenth-grade high school students, whose expectations and needs differ from those of a diverse group of art students, some of whom already possess their own artistic practice. Additionally, the duration of the course was extended from two days to three to allow for a more comprehensive learning experience. Furthermore, a more selective and deliberate approach was taken in the choice of tools, as there was already a preliminary understanding of which tools were most likely to be utilized.

The tasks and information given were identical; every working phase now was 45 instead of 30 minutes, since there were 3 days available. Expecting everything to move a bit slower, we had planned more time for each step in the school workshop. This turned out to be a misjudgement, as the pupils understood the task assignments often faster and then were left with more time overall perfecting their results or making many versions, as seen in Appendix E.3.

After the initial evaluation, it was evident that some of the tools were not used as often and were identified as not essential for the workshop. The room in the school was also a bit smaller, so among some non-used hand tools, the plastic shredder and the oven were not installed. This reduced overall workflow complexity and also helped in making the entire concept more easily transportable.

4.6. Structural and Methodological insights

Overall, in the second Workshop, a much clearer group commitment led to clearer progressions in the uploads. Whereas in the first workshop, many participants first explored some material aspect with experiments, documented that and then often switched the object of research, along with sometimes switching the group of research, according to the current interests, in the second iteration all participants were commited to their initially formed groups. From a documentation perspective, this proved easier to trace and analyse, but both workingstyles were welcomed and executable in the workshop framework. All pupils tested their markers for readability and then inserted them in each photo.

Another difference was the stronger topical commitment by participants visible in the second iteration of the Workshop. Each group selected a Research focus not oriented along processes, but along a theme, one example being Plastic flowers in Figure 34. In accordance with the theme, many different productive processes were tried out and iteratively assessed. This difference in working styles between both groups observed, where the pupils were driven by a thematic and project-oriented approach, and the art students responded in a more open experimentation, more driven by machine workflows.

While the proposed methodology was able to accomodate both working styles, this diversity in approaches, which might have demographic underlying reasons further underlines the utility of a student-led approach, since it adapts by design to the specific needs and inquiries of the group at hand.

Figure 34

Different plastic flowers produced in the second iteration at studio einszwovier

Note. This group set out to find ways of quickly producing plastic flowers from thin sheets and wire. Once happy with a particular method, the group started a process optimization, trying to produce the flowers as fast as possible. *Image Credit: Photos by the author.*

4.6.1. Conclusion

The workshop demonstrated a significant shift in participants' perceptions of plastic, fostering a newfound appreciation for its potential as a reusable material rather than mere waste. Through hands-on experimentation, collaborative engagement, and structured documentation, attendees developed both technical skills and a deeper understanding of the complexities of plastic manipulation and recycling. A key strength of the workshop was its open-ended, process-driven approach. By prioritizing exploration over predetermined outcomes, participants felt liberated to experiment, test limits, and innovate without the pressure of creating a final product. The interactive nature of the sessions also reinforced knowledge retention and encouraged creative problem-solving.

4.6.1. Conclusion

Collaboration played a vital role in the success of the workshop, as peer-to-peer learning and collective troubleshooting enriched the experience. Participants actively supported one another, sharing insights and techniques, which contributed to a more dynamic and inclusive learning environment. The integration of the UploadStation further enhanced the documentation process, reinforcing knowledge transfer and allowing for structured reflection.

Looking ahead, future iterations of the workshop can build on this foundation by refining the methodologies introduced, expanding accessibility, and exploring new applications for the techniques developed. Incorporating additional interdisciplinary collaborations and extending the timeframe for deeper experimentation could further enrich participants' experiences. Ultimately, the workshop proved to be a valuable initiative in encouraging sustainable practices, promoting creative engagement with material reuse, and fostering a mindset shift towards responsible design and circular economy principles.

Considered together, the participant engagement, their findings, collaboration, and ability to transfer context-sensitive knowledge to the archive, as well as their overall positive feedback, indicate that the workshop format was successful. The structured yet flexible approach allowed participants to explore, document, and innovate while fostering a collaborative learning environment. These outcomes suggest that this format can serve as a strong foundation for future workshops aiming to integrate material experimentation, knowledge-sharing, and sustainability-driven design.

In the following chapter, Section 5, the focus will shift to exploring potential refinements to the workshop format, assessing its broader applicability, and identifying strategies to enhance its impact.

5. Discussion

Having assessed the workshop process and the role of the archive, the question of further utility and applicability arises. Beyond serving as a documentation tool, how can novel archiving practices be effectively integrated into artistic research and practice? Can the act of archiving itself become an active and evolving part of knowledge creation, rather than merely a means of preservation? Another key aspect is the bottom-up configuration of the entire learning structure. Have we seen enough evidence that people utilize the increased authorship and agency they are handed through the tooling and structure of the workshop?

Additionally, an important consideration is whether knowledge progression is evident over the course of the uploads. Do participants build upon their own and others' contributions, forming a dynamic and interconnected body of research? Understanding how knowledge accumulates and how its accessibility changes within the archive can provide valuable insights into its long-term effectiveness. Identifying ways to encourage sustained interaction with the archive could enhance its role as a knowledge-sharing platform. Furthermore, it is essential to critically examine the feasibility of an actual overwriting of the perception of *plastics-as-waste* in the contexts that have been established.

The Workshop, with its now laid out evaluation will be situated again in the contextual framework established in Section 2. This chapter will explore these questions, considering potential refinements to the archive structure, strategies for fostering ongoing participation, and broader implications for artistic and research-based documentation practices.

5.1. Choices of Medium

Many design choices have already been addressed throughout Section 3, below are a few more considerations that could be reconfigured in the future. Before discussing components of the Machine Archivist, the rationale for the necessity of an archive as such should be revisited. As laid out in Section 2.2.5, the Archive forms a crucial component for any collective learning process. While not every research will necessarily benefit from this exact archival implementation, our tools and our infrastructure necessarily mediate both our individual worldview and also our ability to communicate it to others, as Ihde (2009) already pointed out. The specific implementation of our tools matters and impacts the outcome of research. Creating an archiving tool that places the work (and the joy?) of archiving on the collective itself here is a conscious choice and seeks a more transparent and straightforward archival process. It might seem counterintuitive that it hopes to achieve that by obfuscating, hiding and automating certain parts of the process, but that is exactly what makes a tool a tool: it gives certain affordances and it is up to a user to determine whether something is the right tool for a job.

For future work, it might also be interesting to examine the possibility that actively participating in documenting, thereby contributing towards a collective effort that is later on publicly visible, might exen be a motivating factor in itself. A contribution to an archive in the present configuration presupposes only the curatory work of choosing what to communicate in an image. All digital work such as data storage, interlinking and publication is relieved from a participant, enabling a less limited focus on the central question of “what wants to be communicated”.

In the case of an archive, there are also considerations of value inherent. Refer back again to the lone crazy individual deciding to keep an object despite society evaluating it as transient, proposed by Thompson (2017): Relying on this single trendsetter figure yields a concentrated distribution of power. A small group, or an individual, when determined enough can dictate what is valuable to society. By placing the archiving activity on a community, like done with Wikipedia, and like done here, the question of what is of value is out in the open, ready to be debated, and distributed. While this does not make value considerations easier to resolve, it opens up questions about valuation itself, a welcome debate when re-valuation is the stated goal of a community.

5.1.1. Paper, connecting the analogue and the digital

As outlined in Section 3.4, paper is intentionally chosen as the medium. The importance of the choice of the documentation medium becomes evident when revisiting the idea of *affordances*. Having a camera and an easily integrable process of archiving not only gives us the affordances of paper (Norman, 2013), but is effectively able to sustain these advantages and layer digital affordances like the relational knowledge graph presented in Figure 18. The documentation process as used here, lets us have the cake and eat it, too. Besides a single

Keypress, it does not require any further digital interaction from its user. This arguably lowers participatory hurdles in collective archiving, while it hopes to sustain authorship.

Further support of the idea that paper can be digitally extended in a useful manner comes from Wimmer (2018). The »Paper:Drive« exhibition (Ness et al., 2025) adopts a similar research stance and introduces the term of a *neo-analogue tool*. The Machine Archivist is in line with these considerations and also hopes to become neo-analogue in the sense that it retains important haptic features for learning, while layering digital aspects on top in a helpful and structural manner.

5.1.2. The choice of the Camera

In fairness, integrating a camera with a fixed viewport also restricts the potential forms of documentation and fails to fully eliminate prescriptions. If images are chosen as carriers of information, certain types of information become salient, while others are not. Movement, scent, and texture are just a few examples of what is compromised in this decision. A camera also brings other constraints like being sensitive to lighting conditions and being tricky to set up consistently. However, an image combined with text recognition does preserve many of the advantages important to both, the analog and the digital. As a data type, Images and Text, in Markdown Format (Section 3.4.3), are both reasonably good contenders for an archive and have fungibility both on the Internet and other forms of presentation later on. It is a space-efficient solution, both in terms of the amount of digital data stored, as well as striking the right compromises by not imposing too much on the freedom of expression in documenting. Nevertheless, 3D scanning might provide an interesting new avenue for documenting purposes, should the amount of data necessary and complexity of use decrease in the future, bringing its ease of use closer to that of a webcam.

5.2. Revisiting the Contextual framework

The workshop format, inspired by the Bauhaus “Materialstudien”[20], successfully encouraged direct engagement with plastic, fostering an appreciation of its material properties.

Rubbish Theory (Thompson, 2017) suggests that value is socially constructed; the workshop demonstrated that hands-on interaction can shift an object’s category from

[20] see Section 2.2.4

“rubbish” to a valuable resource. From several points of feedback presented in Section 4, it can be gathered that a shift in perspective on the nature of plastic did take place.

The framework of the *Temporary Autonomous Zone* (Bey, 2011) and the *liminal* as defined by Żyniewicz (2023) can be applied to the workshop as a performative space where participants were freed from conventional consumerist waste narratives and could redefine plastic through authentic material exploration. The setting itself contributed to this redefinition, evident in numerous instances where peer-teaching and collaboration among the participants took place. A temporary community was formed, with no other motivators than learning communally, giving initial credibility towards the idea that a workshop format can help establish bottom-up exploratory practices. It is of course too much of a burden on a single workshop to expect lasting societal change; nevertheless, an initial prototype scaffolding was set and remains a viable option to foster peer learning.

Material Ecocriticism and the concept of *storied bodies* (Iovino & Oppermann, 2014) suggest that materials carry histories and embedded narratives. Participants shifted from viewing plastic as mere waste to recognizing it as part of a circular material story, actively shaping its second life through hands-on interventions. The transmattering introduced by Żyniewicz (2023) and elaborated in Section 2.2 effectively applies also here. The process of physically manipulating plastics helped participants rewrite its meaning, moving it from a disposable item to an object of potential durability and craftsmanship.

We could observe that meaning-making is an embedded process, one that is greatly aided by the interpersonal configuration in peer-to-peer learning.

5.3. Towards a scavenging gaze in education

The debate over the structure of the anti-capitalist revolution has long been a central issue in anarchist thought. While some advocate for violent struggle, akin to Leninist approaches, others emphasize the necessity of cultivating small, utopian communities that serve as the foundation for broader social transformation. This concept, often associated with Gustav Landauer, suggests that anarchism cannot be achieved through abrupt, forceful revolution but rather through the gradual formation of self-sustaining, liberated spaces. These “seeds” of a new society, once sufficiently developed, would spread and ultimately render the existing system obsolete, leading to an unbloody revolution. This perspective aligns with the broader anarchist rejection of centralized authority and belief in prefigurative politics, a perspective that perfectly embodies peer-to-peer learning on equitable terms. Just as the argument before was made by Köster (2024) that the existence of glass recycling containers and recycling determines *how* and even whether at all we recycle, learning environments certainly shape how we learn.

This concept is reminiscent of the Temporary Autonomous Zone and the Liminal Object introduced in Section 2.2.3.1 and Section 2.2.3. The more nodes and seed-places there are, the closer we are to a *permanent* autonomous zone, one that can reasonably be understood as a sustainable utopia. This permanence is something that Hakim Bey later added as a possibility too (Bey, 2011), acknowledging a conceptual bridge from a single workshop with performative agency to a more liberated self as a whole.

Following that, we as a society should design and implement more spaces that function as Temporary Autonomous Zones, where discarded materials are creatively explored outside capitalist production cycles.

One step towards that could be to salvage what is still salvageable from the old image of the Hacker's Ethic, first formulated at MIT in the 60s: People are able to motivate themselves to learn, to create, to transform, if they just get the right infrastructure - access to a computer (Himanen, 2001). Consider this News snippet from the 1984 "Hackerbibel", an unofficial media of the Chaos Computer Club (CCC), recognizing the impact of "hackers"[21]:

> "No other group that I know of has set out to liberate a technology and succeeded. They not only did so against the active disinterest of corporate America, their success forced corporate America to adopt their style in the end. In reorganizing the Information Age around the individual, via personal Computers, the hackers may well have saved the American economy. High tech is now something that mass consumers do, rather than just have done to them, and that's a hot item in the world."
>
> — Holland (1985, p. 23)

While I do concur that the mentioned transformation happened, I would de-emphasize the *individual* and argue that they have achieved the transformation precisely because they had the communities, the infrastructure and the shared knowledge.

[21] arguably a self-description - the CCC is a prominent Institution for *hackers*, even today.

Hackers, pirates, scavengers, and *students* are all motivated by *sharing*, their knowledge, their results, and their community.

The scavenger's gaze, as explored through practices like dumpster diving as discussed in Section 2.2.3.3, offers a transformative way to rethink value in education. Just as scavengers reclaim discarded items, this perspective encourages us to see undervalued aspects of learning, such as informal knowledge, hands-on experiences, and non-traditional methodologies, as vital components of the educational process. This is in keeping with the pedagogical conceptions of the Bauhaus Vorkurs under Albers, which was actively working towards connecting the materiality and its perception with its designerly potentials, essentially training towards a *creator's gaze* (Engels, 2021).

Rather than viewing education as a rigid, consumption-based system, the scavenger gaze promotes active engagement with the material, repurposing ideas, and reshaping learning through creative practice.

5.4. From Rubbish to Doorway

Critiquing and expanding upon the Rubbish analogy by Thompson as introduced in Figure 2, Hetherington (2004) gives us a way to reinterpret the "fixed" notion of Rubbish and how an object enters that class. She makes clear that the very act of disposal as a ritual, deserves more scrutiny here:

> "This [consumption-] ethics is premised on a notion of the care for the absent, a making of the self through an encounter with its presence, and a concern for its possible return if the conduits through which it is moved are not managed effectively. Issues of social membership, recognition, order, acceptance, status, honour, self-worth are based not just on how one consumes but also on how one disposes."
>
> — Hetherington (2004, p. 171)

Rather, the author introduces the metaphorical image of a doorway, as a better image than the rubbish bin for discarding:

> "To attend a door is a tactile or haptic encounter with the material world. Who has a hand on the door (or the market) matters. But within such consumer relations we cannot rely on the supposed hidden hand of the market to guide us, nor always on the

> visible (first) hand of the gift. Rather it is often our own second hand, a receiving as well as a giving hand, a hand that moves value on, that matters most. The handedness of the market, a consumer market in which disposal is a key part, is one of such translations as are constituted through the 'passing on' of this capacity for secondhandedness."
>
> — Hetherington (2004, p. 171)

Implied here is the idea that disposal can happen in many, often dignified ways. The author even likens the disposal of objects to the ritualized disposal of our human dead. Disposing of somebody, instead of something, comes in all cultures with a large construction of rites, to ease the loss for the remaining people. Who eases us when disposing of something would be an entirely different experience and concept when it is done with further potential use in mind. We could respect and retain the value in objects, if not for us, then at least for others. We could (and we often do) send our used, to-be-discarded objects to others that might retain or transform their use. We have flea markets, we have the universal practice of *Sperrmüll*[22] which tacitly acknowledges that others might come and *scavenge* our discarded objects. All of this can be either encouraged or discouraged by infrastructures.

One important infrastructure there is the law itself, evidently shaping our affordances. The rules for Sperrmüll, for example differ widely throughout Germany, with some municipalities declaring the taking of other peoples *Sperrmüll* as theft.

5.5. The Right to Destroy?

The ancient roman *ius abutendi*, the right to destroy, or sometimes the right of disposal, was considered an essential pillar of ownership. It is not without debate though and in a world under growing resource scarcity has been challenged a few times already. Render (2025), while primarily focused on "planned obsolescence" and the imperative of avoiding waste from a manufacturers perspective, Locke's formulation of property, which is deeply incorporated into American law, also has far-reaching imperatives for owners (or, rather - consumers) themselves. Ownership, here entails a *stewardship* where abandoning, or discarding an object has absolutely no place. Objects of property can be transferred or transformed, never wasted. In the Lockean sense, *adverse possesion*[23], is not permissible, it is not ownership at all. Therefore, anybody that then proves a better steward can claim

[22] "putting large discarded objects on the curbside for scheduled pickups"
[23] owning something and abandoning it, letting it go to waste at the same time

ownership anew[24]. This is a very intuitive and also practical argument if we think about the Berlin Law, the *Zweckentfremdungsverbotsgesetz* that disallows wasting usable living space (Gesetz in Berlin, 2013).

So, even when going as far as looking into the very origins of liberal law formulation, waste seems to be a disputable category. It could be reasonably substituted with the much more entangled conception of *secondhandedness* as introduced by Hetherington (2004).

5.6. Future directions

When treated as a infrastructural scaffolding, the object of research becomes exchangeable. The area of application then extends beyond plastics and could be used to explore materialities not yet present in schools and universities. The workshop format as such is already en route to becoming integrated into my teaching practice and will be used again in the context of a students' project-week fittingly themed "Transformations". Many elements resurface in considerations of structuring future students spaces and the core idea, that engagement grows best when a sense of agency is present, is present in all other course formats currently under development.

As we conceptualize many making-workshops centered around the 3D printer and the accessibility of printing continually increases (Mikula et al., 2021), its versatility as a tool in education is ever-more widely recognized. Although the recycling-to-filament process got discarded in the context of this work, the appeal remains and further research is warranted, creating filament as a much more versatile material form compared to plates. But even without truly circular recycling in place, creating with plastics opens up new avenues in education.

One idea is to explore expanding the wonderfully gamified levelling system of Steph Piper (2024) into a more expansive, multi-material framework that includes plastic recycling as one aspect. A "skill tree" for waste materials could be developed, guiding participants through progressive challenges in plastic manipulation and reuse. The playful learning approach to making is something that we will explore further in our work with studio einszwovier. There is also some potential in combining the physical skill-points with the kind of digital backbone the Machine Archivist could provide. The methodology also does

[24] "that would then be the Pirate, the Hacker or the Scavenger, all figures challenging this adverse possesion when it occurs"

not have to stay restricted around the workshop at all: while it seems a useful temporary breeding ground for the tinkering progress, a space needs to be defined with more lasting infrastructure than just workshops. One avenue could be material stations, partly integrated and intersecting traditional curricula at many points, forming a secondary and complementary infrastructure in education as exemplified by (Meer, 2024)

Using Archives as a form of collective knowledge-making was also already a factor in the Material Gestures Course by Anne Holtrop (Holtrop, n.d.). A further reference here is presented through the “Mobile Library”, a project by the Asia Art Archive (AAA) (2022). The learning progress achieved through interaction with the library, later shown at Documenta fifteen, is demonstrating that art education thought as infrastructure does not end by providing access to books and knowledge; it can take an active, interventionist role, enabling spaces for communication and networking.

The Role of Play and Experimentation in Education is often recognized and gaining traction also in Education Sciences. Playful Learning and its benefits are increasingly discussed (Whitton, 2018). Further arguments for a bottom-up learning approach are delivered by Kyrou & Rafehi (2023), where students are invited to co-design their own learning environments. The increased sensation of agency is a key contributor here and arguably takes a similar perspective on ownership in learning as the here proposed workshop format.

There are numerous instances where infrastructure can foster co-creation and enable learning environments, also evident in the emergence of maker-spaces (Sheridan et al., 2014). Makerspaces so far did not figure at all in the conceptualization of the workshop. Yet, studio einszwowier is a makerspace. To understand better what that entails, Sheridan et al. made out 4 core components of a studio that can be called a makerspace:

> “[We] identified four key “studio structures” as central to the design of studio learning environments: (1) in demonstration-lectures, teachers pose open-ended challenges, show exemplars, and demonstrate processes to engage and inform students, (2) in students-at-work, students work on their art and teachers circle the room observing and giving “just-in-time” instruction, (3) in critiques, the working process is paused as the

> group collectively reflects on student work, and (4) in exhibitions, students' work is shared with a community beyond the studio classroom."
>
> — Sheridan et al. (2014, p. 508)

While the term Makerspace is overused and has many overlapping definitions, sticking to these 4 central observations of a *studio-structure* we can arguably attribute a studio-structure to the work at hand, with a public archive fulfilling pillar (4). Sheridan et al. (2014) observe: "learning is in and for the making". They identify a process-based interest: "in tinkering, in figuring things out, in playing with materials and tools" and importantly, a shared community. This sounds a lot like a *Pirate-Utopia* to me, an environment and learning process based on skill-sharing, peer-learning, hacking, tinkering, scavenging. A single workshop does not define a space on its own, but it creates a Temporary Autonomous Zone, a tiny unit of shared agency and instigates a re-valuation process.

If plastic is viewed as a cultural artifact rather than just waste, could it be archived, exhibited, or treated as a medium for artistic and social commentary?

Thank you for taking the time to read my work.

In the following, find the references used and further documentation materials in the Appendix.

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Contents of the Appendix

Appendix A

Acknowledgements

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Appendix B

Utilization of Artificial Intelligence and other Writing Tools

I hereby declare that I have only used permitted and documented tools. I assure that the labeling of AI usage is complete. In the Bibliography, I have listed the AI tools used, including their product names and sources.

I confirm that I have not used any AI-based tools that have been explicitly prohibited in writing by the examiner. I am aware that the use of texts or other content and products generated by AI-based tools does not guarantee their quality. I take full responsibility for incorporating any machine-generated passages and acknowledge accountability for any errors or distortions produced by AI, incorrect references, violations of data protection and copyright laws, or plagiarism.

Throughout the creation of this study paper, I have worked independently and maintained full control over the use of IT-/AI-assisted writing tools.

Appendix C

Additional tools in the Setup

C.1 The Oven

Figure 1

The Oven

Note. [Image location in the archive] *Image Credit: Photo by the author.*

The oven was planned for a batch process, enabling larger and thicker sheet goods through preheating materials in the oven. Workshop attendants also used it creatively for thermoforming processes, something not anticipated beforehand.

Despite that, the oven feels most useful for advanced processes and is one of the more optional tools in the introductory context of the workshop. It was also left out for the second iteration.

C.2 Additional Postprocessing Descriptions

Welding Iron.

For some portable soldering irons already at hand, I found additional tips in the form of a hobbyknife. This made them work effectively as a hot-knife, enabling small scale hot-plate welding and efficient plastic cutting. They also serve well for cleaning up edges of parts. A soldering iron comes designed for small and detailed work, it proved versatile and accessible for many finer tasks. Some participants noticed a lack of power in the devices, making this version only suitable for very fine detail-work.

Figure 2

Using the hot knife

Note. Here, the hot knife was explored not only as a cutting tool, but also for its plastic welding potential. *Image Credits: Beril Ece Güler / InKüLe*

Hot Air Gun. The hot air guns proved incredibly useful and versatile as they provided fine-grained control and selective heat application onto parts. Typically, the hot air gun is the tool of choice for removing strings and flakes from a CNC-cutting job, but it is potentially powerful enough to heat up entire parts and is the only tool in this context that gives the user fine control over heat application.

Multi-tool. As a precaution, I had brought bunch of hand- and power tools, and the multi-tool was probably the biggest discovery there: It proved very apt at cutting cleanly through plastic and will be a staple tool in upcoming plastic workshops. See Figure 14 for an example.

Appendix D

Additional Software description

Several feature flags are available, enabling rapid adaptation to changing circumstances. The available configuration options are:

- `--camera` Sets the camera index to use for capturing the image. This option requires an integer value. By default, it is set to 0, which would then select the first available camera.
- `--image` Specifies the path to an image file to use for processing instead of capturing a new image from the camera. This option is only needed in case something that is already digital needs to be uploaded, like a digital sketch, for example.
- `--upload` This option can enable or disable the upload to Logseq, manipulating whether Internet will be required.
- `--ocr-processor` Chooses the OCR (Optical Character Recognition) processor. The available options are:
    - EasyOCR
    - Tesseract
    - Ollama-OCR (uses Ollama for image description)
    - Mac-Framework-Vision (uses macOS's Vision framework via pyobjC)

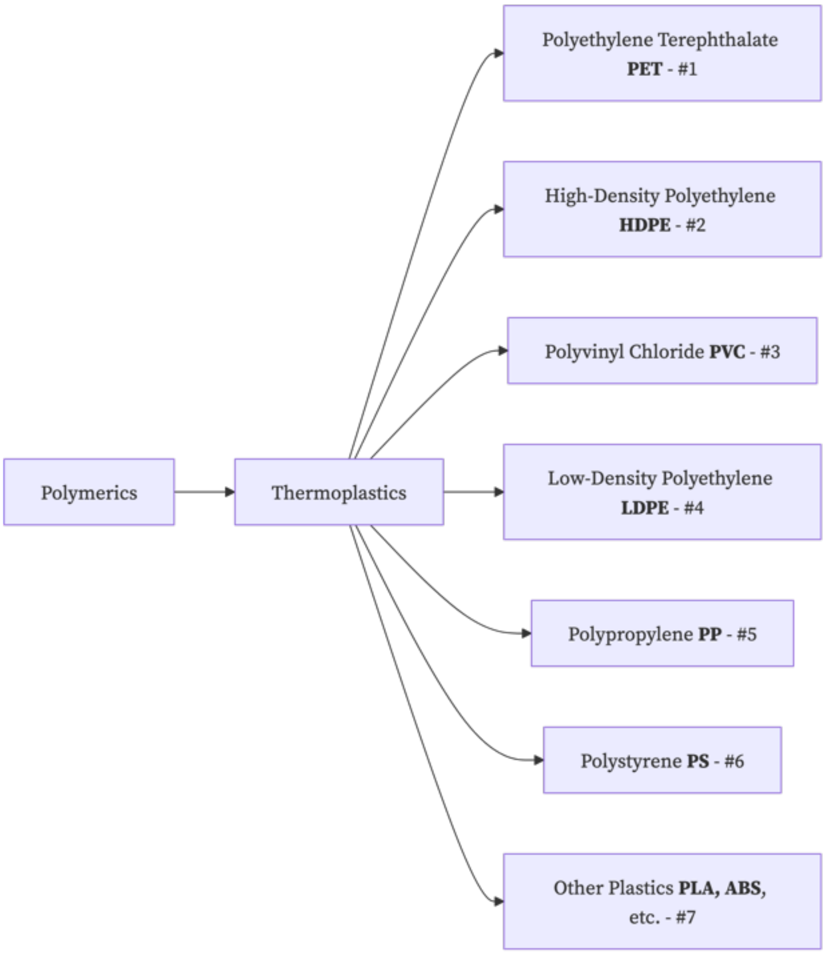
  By default, it is set to "pyobjC".
- `--use-ollama-caption` Enable this option to use Ollama for generating image descriptions (captions). By default, this is disabled (False).
- `--use-ollama-ocr` Use Ollama for OCR instead of the default OCR processor by enabling this option. By default, this is disabled (False).
- `--check-markers` This option enables checking for markers in the image. No template matching is happening if disabled.
- `--upload-marked-image` Specifies whether to also upload the image with detected markers visualized. By default, this is disabled (False).

Appendix E

Teaching Materials used in the Workshops

Figure 3

The commonly identified subclasses of the thermoplastics (Katz, 1998; Precious Plastic, 2025)



Note. While this overview cannot be exhaustive, since there are hundreds of subclasses, and it is a little futile to keep track of novel materials that producers come up with every time they need slightly tweaked properties and adjust the additives and formulations, this list represents the 7 internationally recognized broad categories that many countries regulate in recycling programs. (ASTM International, 2019; Society of the Plastics Industry, 1988)

E.1 Visual properties

Type & Name	**Properties**	**Common Use**	**Burning**
PET (Polyethylene Terephthalate)	Clear, tough, solvent-resistant, barrier to gas and moisture, softens at 80°C	Soft drink, water bottles, salad domes, biscuit trays, food containers	Yellow flame, little smoke
HDPE (High-Density Polyethylene)	Hard to semi-flexible, resistant to chemicals and moisture, waxy surface, softens at 75°C	Shopping bags, freezer bags, milk bottles, juice bottles, ice cream containers, shampoo bottles, crates	Difficult to ignite, smells like candle
PVC (Polyvinyl Chloride)	Strong, tough, can be clear and solvent-resistant, softens at 60°C	Cosmetic containers, electrical conduit, plumbing pipes, blister packs, roof sheeting, garden hose	Yellow flame, green spurts
LDPE (Low-Density Polyethylene)	Soft, flexible, waxy surface, scratches easily, softens at 70°C	Cling wrap, garbage bags, squeeze bottles, refuse bags, mulch film	Difficult to ignite, smells like candle
PP (Polypropylene)	Hard but still flexible, waxy surface, translucent, withstands solvents, softens at 140°C	Bottles, ice cream tubes, straws, flower pots, dishes, garden furniture, food containers	Blue yellow tipped flame
PS (Polystyrene)	Clear, glassy, opaque, semi-tough, softens at 95°C	CD cases, plastic cutlery, imitation glass, foamed meat trays, brittle toys	Dense smoke
OTHER (All Other Plastics)	Properties depend on the type of plastic	Automotive, electronics, packaging	All other plastics

The structural overview visible here is taken from Melbourne Precious Plastic et al. (2020).

E.1.1 Density testing

Floats on	Alcohol	Vegetable Oil	Water
PET	No	No	No
HDPE	No	No	Yes
PVC	No	No	No
LDPE	Yes	No	Yes
PP	Yes	Yes	Yes
PS	No	No	No

Here is an overview over the floating properties taken from Melbourne Precious Plastic et al. (2020).

E.2 Further Workshop Documentation

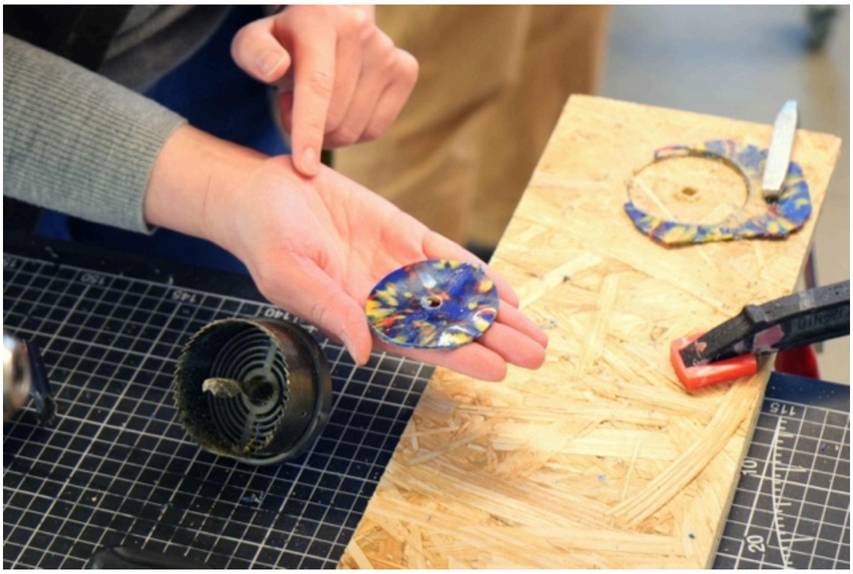
Figure 4

Implicit zoning through a prepared table configuration

Note. *Image Credit: Beril Ece Güler / InKüLe*

Figure 5

Hole-saw as an efficient tool for plastics



Note. An important learning that often cannot be transported through explanations alone: creative productive problems often have many different solutions, and it is easy to fall into the *"Tool Trap"*, where the availability of a tool dictates the solution. Sometimes a hole saw produces circles more efficiently than a CNC.

Image Credit: Beril Ece Güler / InKüLe

E.2.1 The Exposé of Workshop 1

> This hands-on workshop invites participants to actively address plastic pollution by transforming waste into durable, meaningful objects. Unlike traditional industrial recycling, which often prioritizes economic over ecological concerns, this workshop empowers individuals to reclaim and re-purpose plastic in a way that fosters creativity, sustainability, and personal agency. The workshop unfolds in two sessions. In the first, participants will sort, wash, and shred plastic waste using a Precious Plastic Shredder, creating small flakes. These flakes will then be heated in a panini press, transforming them into a malleable plastic mass, which will be molded using a DIY plastic sheet press. The resulting sheets will be finished with woodworking tools, and participants can add personal engravings with a CNC machine, allowing for unique, patterned designs. The final products, shaped through a combination of heat, pressure, and craftsmanship, will reflect the individual designs and creativity of each participant. Whether through engraving or coloring, participants will gain hands-on experience with the potential of up-cycling plastic waste into functional, aesthetic objects. This workshop offers a tangible way to engage with the global issue of plastic pollution, encouraging participants to reconsider the life cycle of everyday materials. It is a way of reformulating transient objects into durable/lasting objects, an alchemical formula for design.
>
> — InKüLe, Immaterialities: Reshaping Plastic (Open Call), Text: Aron Petau

E.2.2 Full transcript of participant feedback Workshop 1

Note. This transcript was co-created by Whisper, a large language model that utilizes speech-to-text features (Radford et al., 2022). The feedback is incomplete because of poor audio quality. I checked and edited it for correctness.

Prompted Questions:

- Give feedback on the workshop and its structure.
- Has your perception towards plastic changed in any way?
- What are your main takeaways?

Plastic and oil are like big enemies when you talk about pollution. But now we can easily see that new things can be made out of old things, which is really nice. I think we played around with so many things, and it was great to experiment with everything, even though there wasn't one final product in the end. I think that was really good because, at least for me, in the beginning, I was thinking about which product to make. It was nice that we had research groups, so we weren't focusing on the final product but more on the process — on finding something out. That was really nice because it led to more experiments. It was more about discovering new things instead of just trying to achieve something.

I love plastic now after the workshop.

I showed this already, but this one I did with a welding iron was actually very easy. It's made of 3D-printed plates, which are very easily connectable and pretty stable. I just touched it with the iron on the side where the pieces meet for a few seconds, and it became very strong. It's a bit like glue, actually, so that was very interesting. PLA is really nice to work with. It was interesting to see. If there were more tools — like that Trichter thing — I think I would like to experiment more with it. But yeah, I forgot the name again… Spritzguss! Ah, Injection Molding.

I got some of the materials from a place in Moabit. I don't have Instagram, but maybe you can see it here. It's a community workshop that anyone can visit, and they have way cooler tools than I do. They have, for example, an injection molding machine, which is basically a stamp that presses down with a huge amount of force. You put plastic in, it melts, and comes out of a nozzle into a hollow aluminum block. They can make beams, which is something I can't do yet. If you got motivated, feel free to check them out. I discovered them two weeks ago, and especially the beam press transformed my options. I'm really thinking of doing more with beams because they are structural—you can make furniture, outdoor sculptures, really strong and stable stuff—and they're super fast to produce. The place is called Wertstatt Moabit.

They work on a donation basis, so you just go there. If Moabit is far for you, there's also the Precious Plastic network. Maybe you've heard of them? They're internationally quite big, and they have a map with workspaces, machine builders, community points, and collection points. If you have a lot of nice trash or need some, this is a great resource to check out.

I've been experimenting with spheres for years, sometimes big, sometimes small. I love how they are such a cool 3D object that you can make out of 2D rings. I was inspired by everyone here because I was working with plastic for the first time. It takes time to bring ideas to life, especially when they're objects, and I really appreciated how many people helped me along the way—explaining how to use the drill, the printer, and how to assemble it. It was a real group effort, and I loved that.

I also really enjoyed the documentation moments. When you're deep in the making process, you forget to reflect on the material. The documentation process gives you a little time to do that.

Plastic is fun to work with, but I also feel unsure about it. On one hand, it's empowering — we can make things out of waste — but on the other, are we just producing more plastic in the end? We didn't really solve the problem; plastic isn't digestible. Are we encouraging more plastic production? That's a question I've been thinking about. Initially, I wanted a final product to come out of this workshop. I thought it needed to be functional to have value, and I spent months stuck on what that product could be. But eventually, I realized that anything we do here affirms the system we're in. The plastic isn't going away — it's not shrinking — so we might as well use it. It's like the leather jacket debate. If they already exist, is it okay to wear them? Or does that just make wearing leather cool again? The same goes for 3D printing. We use a lot of plastic, and even if we think we can always remake things, is that really sustainable? There's no clear answer, but it's something to consider.

I also liked that there was no pressure to create one specific product. Instead, people explored different research topics, which was really fun. Maybe we struggle to come up with a product because we already have so many. Maybe we don't need to make more. There's so much plastic and so many products already that it's hard to justify adding another one. It was also eye-opening to realize that recycling costs—energy, money, material loss. Some plastic gets mixed with wood and becomes unusable. If it's too thick, you have to discard some. You always lose something in the process. I really liked how open the workshop was. We had so much time to just experiment with different plastics. For me, it was about understanding plastic better—how malleable or not it is. I had many plans, but none of them turned out as expected.

I tried molding plastic onto a bottle in the oven, but it just sagged on both sides. But that's okay — it was great to just play around with all the tools and machines and see what happens. I was trying to make a phone stand, mostly to explore the materials. This one is the toxic one — it should be known forever as "the toxic one." It's really strong, almost like acrylic. I was working with the theme of connections, and I wanted to make something functional. I just need to drill one last hole, and it's done!

I first tried using a thinner piece, but it bent too much, so it didn't work. PLA is better for this. I liked that the workshop was two days. The first day was for exploring, and by the second day, I had a clearer idea of what I wanted to make. The documentation part was also great. I also just printed something random to impress myself, to see what happens. Plastic is always here; in the future, it'll still be here. Modern fossils. I was thinking about making small plastic pieces into jewelry, like connecting different shapes. Have you seen that arm piece with multiple plates? I like this one—it has a nice texture. If you scratch off the wood chips, you can throw it back in. If you really want to help, pull off the tape, too.

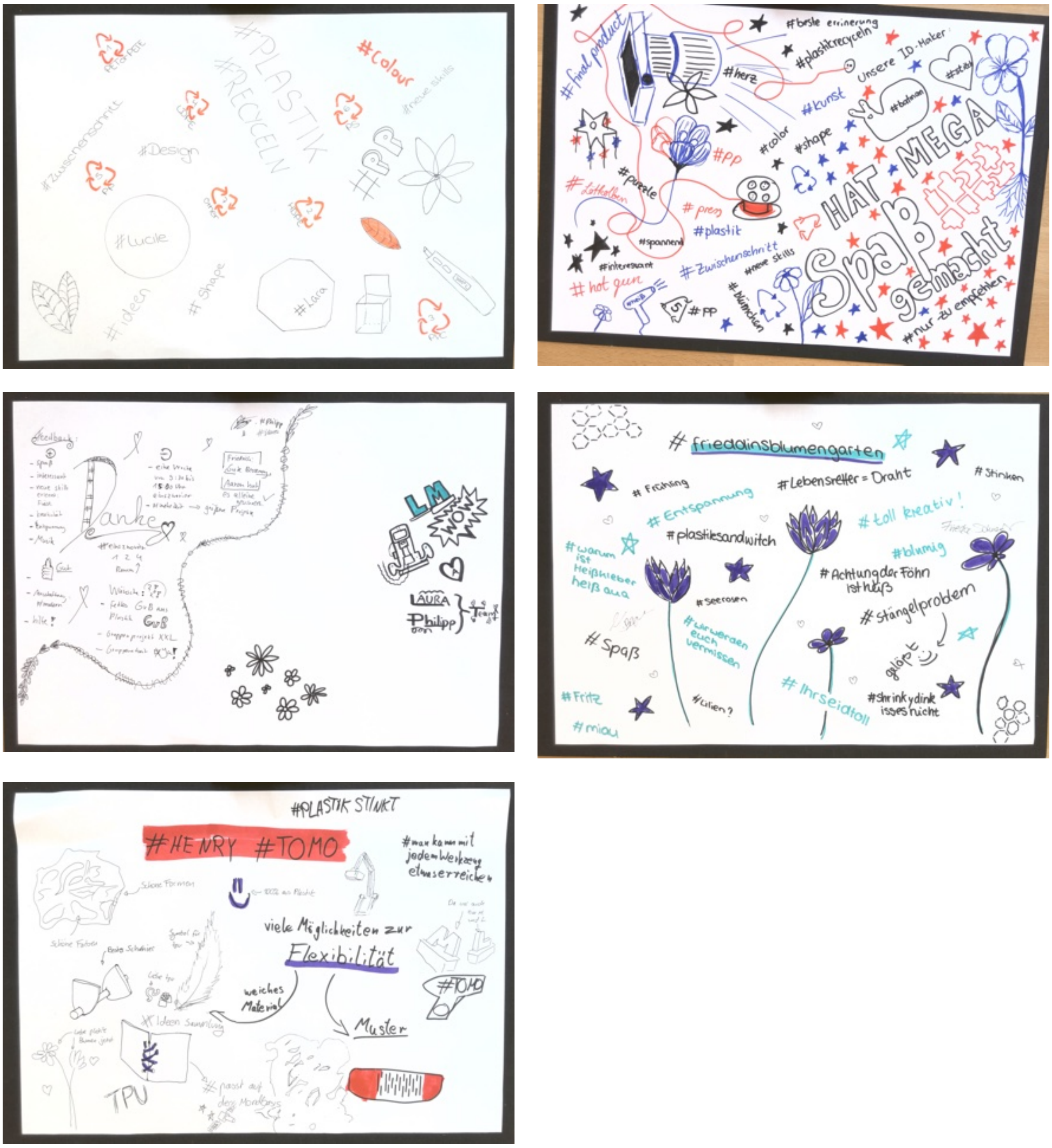
Thanks for all the input! If there's nothing else to share, I'd say we can officially wrap up. If you want to stick around and finish your last steps, feel free—I'm still here for a bit. If you'd like to help clean up, that's also appreciated. This is part of a series, so there will be more workshops. The same channels apply. Next time, I'll try to adapt this workshop for a school, and maybe iteration three will be back here again.

Thank you all!

E.3 Further Workshop Documentation at studio einszwovier

Figure 6

Sketched out feedback from Workshop 2



Note. Each group left a written-down A3 paper filled with their impressions. We call that the guestbook. It serves as a direct medium for communicating firsthand impressions of the workshops. Often, we are surprised to find that elements we didn't consider relevant resonated deeply with many participants. *Image Credit: Photos by the author.*

Figure 7

Archive Uploads Group 1, Reshaping Plastics at studio einszwovier

Note. The group set out to construct Letters in 3D using plates and cutouts from the shaper. Everything was hand-drawn and transferred the the CNC using the Shaper Trace. *Image Credit: Photos by the author.*

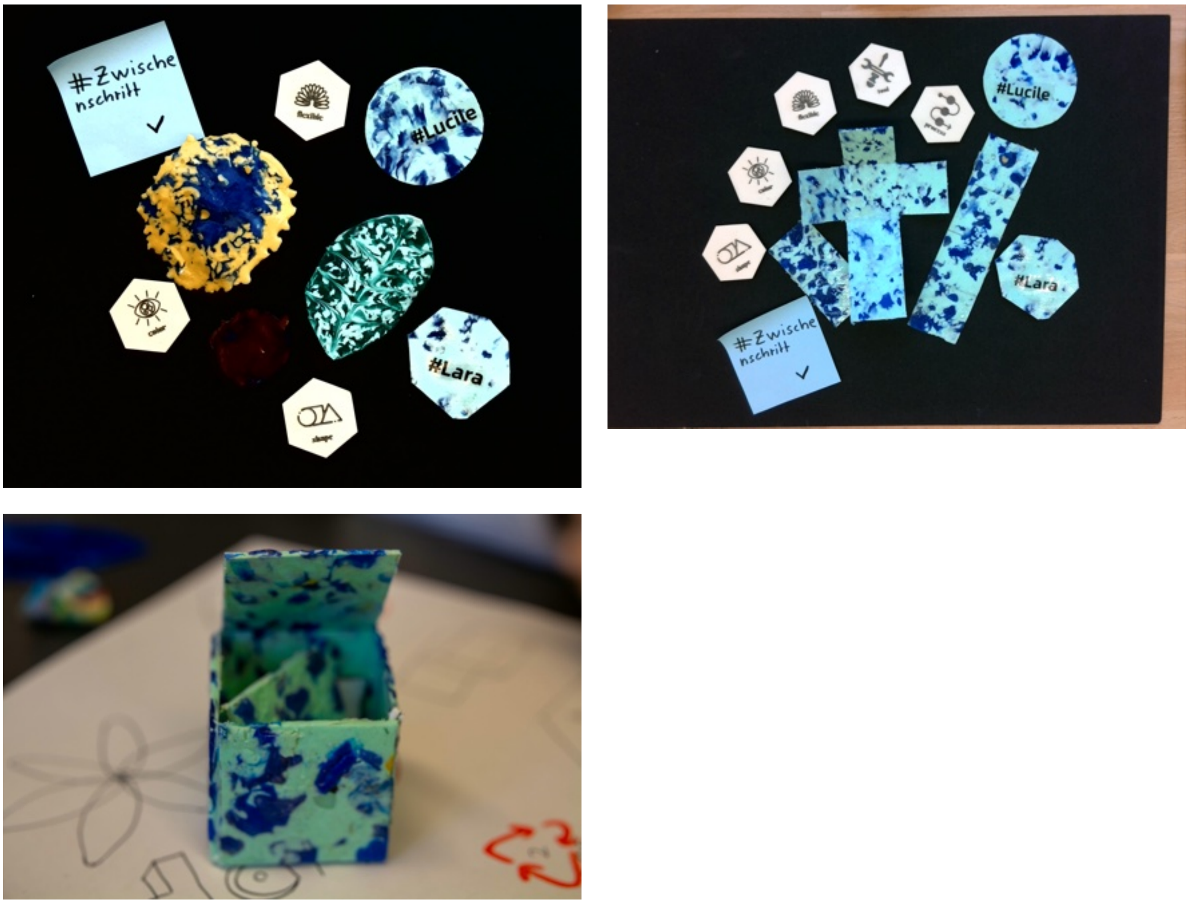
Figure 8

Archive Uploads of Group 3, Reshaping Plastics at studio einszwovier

Note. This group discovered that swirling the hot liquid plastic with sticks holds great potential for shaping and create quite organic forms. They were then using the CNC to cut out a puzzle set. *Image Credit: Photos by the author.*

Figure 9

Archive Uploads Group 4, Reshaping Plastics at studio einszwovier



Note. These two were constructing a plastic box from a single sheet of plastic, borrowing sheet-bending techniques from metal. They were also developing a technique where they patterned the plastics in the molten state to get leafy structures. *Image Credit: Photos by the author.*

E.4 Links to all external Sources

Figure 10

Links to all online sources this work references

The Machine Archivist
forgejo.petau.net/aron/machine_archivist

The relational Archive
archive.petau.net/#/graph

The image Archive
pinry.petau.net

Note. These QR codes link to the online resources displayed under them. In the digital version, all links are clickable; a QR code is only needed in the printed-out version.