DESIGNING FOR ADOPTION: PARTICIPATORY APPROACHES TO WASTE PROCESSING SOLUTIONS IN BEKASI, INDONESIA

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Abstract

This article examines the gap between designers and communities in participatory design practices, using community-adoptable waste processing as a case study. The research was conducted in Mekarmukti and Tanjungbaru, Bekasi, West Java. Critical motivational factors within the community, such as economic benefits and pride, influenced the acceptance of proposed solutions while constraining them to options aligned with local preferences. Designers formulated solutions that sought to accommodate these preferences. This qualitative study employed a participatory action research approach, integrating material exploration methods during the implementation phase. Laboratory-scale experiments were conducted prior to the broader application of the findings. As of this writing, the preparation phase is on going. The results suggest that waste processing solutions are more readily accepted when they align with the community's technical preferences, do not require substantial investment, and avoid significant disruptions to daily routines. A process model is proposed that emphasizes solutions minimizing additional work and behavioral changes. The artifact model remains under development.

Key words: participatory design, waste management, designer, community, gaps

INTRODUCTION

Waste management in communities is not just a physical issue but also involves complex social, cultural, and environmental dimensions. A key challenge lies in the differing perceptions of what constitutes a clean or dirty environment, as well as varying sensitivities to waste-related disturbances. While raising awareness is an important first step, understanding the community's actual waste management practices is equally crucial, as these are often shaped by underlying drivers within the community. Designers can tap into this local knowledge as a valuable resource for crafting appropriate solutions.

A shared understanding between communities and designers can be fostered through participatory methods, which help identify and address community needs. (Jokhu and Kutay, 2020) By engaging in participatory design, designers can collaborate with communities to develop solutions that are sustainable, accessible, and feasible for adoption. However, the success of participatory design hinges on the depth of community involvement. Active engagement is essential for uncovering key issues and opportunities within the community. (Jagtap, 2018) as building empathy through direct experience offers a more comprehensive and accurate perspective.

Community-level waste management has traditionally centered on addressing waste after it has been generated, as communities have no control over the types and quantities of consumer goods produced. (Pongrácz, 2002) However, communities can play an active role in managing waste collection, sorting, and processing on a small scale. (Cai et al., 2021)

Collective efforts in waste management have the potential for a larger impact, particularly when active participation is encouraged. Despite awareness of the harmful effects of improper waste management, many communities face limited options. (Nxumalo et al., 2020) A lack of knowledge about effective waste management remains widespread in many Indonesian cities (Brotosusilo & Handayani, 2020), emphasizing the need for drivers that support community involvement, such as perceptions, behaviors, and tangible benefits. (Farida et al.,

2024; Jiang et al., 2021; Suryawan & Lee, 2023) Skepticism towards waste management initiatives often arises when these efforts, conducted by individuals or small groups, appear to have limited impact. (Budihardjo et al., 2022) Enhancing awareness of the social and economic benefits of community-based waste management could therefore strengthen sustainability. (Oyinlola et al., 2018)

Such community-based approaches can help reduce government expenditure on waste collection, transportation, and disposal, while also extending the lifespan of landfills. However, social conditions and available infrastructure significantly influence how communities handle waste, shaped by both perceptions and behaviors (Jiang et al., 2021) as well as the adequacy of public infrastructure and services. (Cai et al., 2021)

Waste management through recycling is particularly relevant to social dynamics. (Huysman et al., 2015) However, recycling is more closely tied to cultural issues than to social, economic, or environmental factors, as the current production cycle fosters a throwaway culture. (Bridgens et al., 2018) The approach to recycling differs between community-scale and industrial-scale operations, with different environments and community types requiring distinct models. Closed-loop recycling, which involves material purification, is unsuitable for community-scale initiatives due to the high investment costs. (Eriksen et al., 2019)

In contrast, open-loop recycling is more feasible at the community level, as it produces materials that, although of lower quality, have broader applicability. (La Rosa et al., 2021) However, closed-loop recycling can be practical in specific settings, such as the recycling of surgical instrument packaging in hospitals. (Van Straten et al., 2021) Recycling schemes often experience diminishing environmental benefits when their processes become more costly than disposal alternatives. (Huysveld et al., 2019) Key factors influencing recycling-based waste management include economics, social acceptance, technology, market dynamics, and public awareness. (Duan et al., 2021) Design can play a critical role in overcoming these limitations through material-driven approaches, where new

products are developed based on available recycled materials (Ragaert et al., 2020), ensuring that the product value remains comparable to that of newly manufactured goods. (Polyportis et al., 2022)

Based on the established reasoning, it is assumed that community-based waste management through design cannot be approached in a top-down manner. While designers can propose product development, decisions must be grounded in the community's technical preferences and aligned with the specific community context. (Rahardiani et al., 2024) Design can ensure that solutions maintain value comparable to new products. (Polyportis et al., 2022; Rahardiani et al., 2024)

The case study from Mekarmukti and Tanjungbaru, Bekasi, illustrates the crucial role of the community as co-designers in shaping waste management solutions. The differing frameworks between community and designers necessitate a bottom-up approach from designers. Highlighting this approach is essential, as it adds a significant dimension to the research, beyond the more commonly discussed outcomes or workshop processes found in similar studies.

METHODS

This study employs participatory action design, grounded in the perspective that the knowledge of community issues and needs resides within the community itself. (Jokhu & Kutay, 2020; Müller, 2021) Engagement with the community and an in-depth exploration of their waste management practices were conducted from November 2021 to May 2024.

The findings led to the development of a conceptual model for identifying key factors in collective community-based waste management. Data collection involved in-depth interviews with village heads, experts, recycling center managers, and waste bank operators, complemented by discussions with community members and supported by questionnaires.

Field observations and visual documentation were used to understand the geographical characteristics of the community's living environment. Data were gathered from two villages, three hamlets, two waste banks, and one recycling center. Key informants assisted throughout the process, facilitating access

to the community, especially in informal settings. Reflections from each activity were used to continuously inform subsequent activities. (Schön, 2017) To address subjectivity and bias, discussions and workshops were conducted as part of a triangulation effort.

Inspiration Session

This study presents a structured mapping of dominant driving factors to aid in analysis. The mapping is based on Bandura's social cognitive theory (McAlister et al., 2008), which helps establish general criteria. According to the Theory of Planned Behavior (Montano & Kasprzyk, 2008), the driving factors for waste management can be categorized into internal and external factors. Operationally, the collected data were analyzed using diagrams, as illustrated in Figure 1.

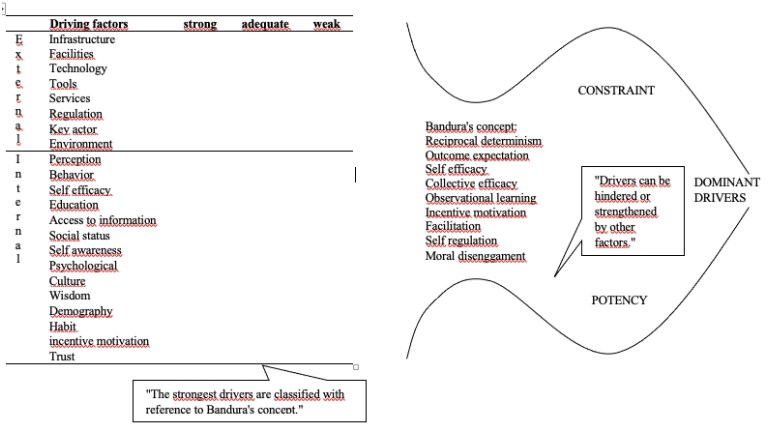

Figure 1. Operational scheme of analysis
Source: developed by authors, 2023.

Ideation Session

In October 2023, this session engaged three experts from both practitioner and academic backgrounds to identify the most promising participatory design actions. The practitioners included a Specialist in Village Economic Development from the Village Development and Empowerment Program, Bekasi, and a Design Thinking Practitioner from the Ministry of Education of

the Republic of Indonesia.

The academic expert was a lecturer in Product Design with a focus on waste management. The session illuminated the interconnections between four key issues: waste management practices, types of waste generated, waste disposal locations, and existing facilities. These issues were mapped diagrammatically, as shown in Figure 2.

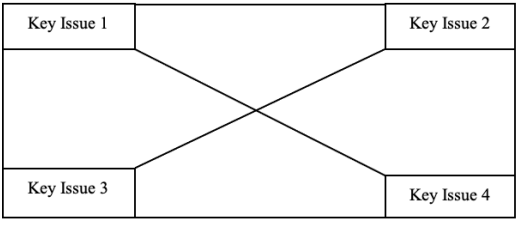

Figure 2. Ideation diagram
Source: developed by authors, 2023.

Implementation Session

In November 2023, a workshop was held with 11 community representatives from Mekarmukti Village, Bekasi, including one village official, four recycling center employees, two homemakers, and four scavengers. The workshop aimed to build on the insights gained during the ideation session and align the vision between the designers and the community. This session focused on refining the issues to identify the most acceptable waste management alternatives. Participants interacted with stimuli, including repurposed waste materials. During the workshop, a consensus was reached on the definition of residual waste, which facilitated a design-focused approach to address it.

Data from the inspiration session were used to guide the selection of residual materials and processing methods that aligned with the community's technical preferences. This activity is proposed as a process model. Following the workshop, material exploration was conducted at the laboratory scale at the ITB campus workshop. The selected residuals were chosen based on their alignment with the types of waste still considered residual by the community and had not been processed at any scale by the community previously.

Equipment and methods were adjusted to fit the community's preferences and capabilities, avoiding lengthy processes and extensive material purification.

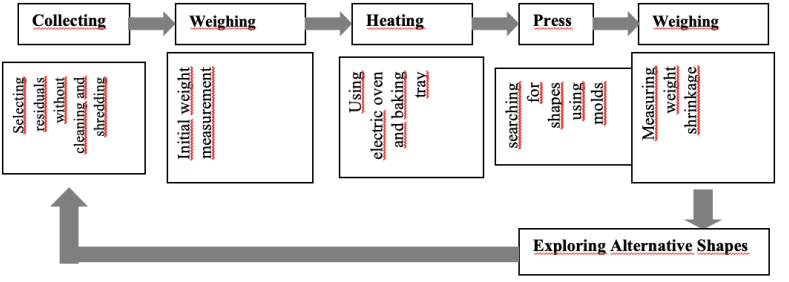

Figure 3. Material exploration flow diagram
Source: developed by authors, 2024.

Village Tanjungbaru, Bekasi, was selected as the site for continuing the participatory design implementation due to the closure of the Recycling Center in Mekarmukti in December 2023, which had originally served as the activity venue. Despite this change, the conceptual and process models developed from the Mekarmukti study can be applied to Tanjungbaru, as the community type and waste generation characteristics are similar. Additionally, the existing relationship between the Mekarmukti Recycling Center managers and the Tanjungbaru Waste Bank managers, both affiliated with PERBANUSA, facilitated the transition to the new site.

RESULT

Identification of Driving Factors

The driving factors were identified based on the factors encountered during data collection, particularly from Mekarmukti, and were subsequently integrated using the diagram shown in Figure 1. Each significant driver was re-evaluated against the internal constraints identified from the data. The results of this analysis are illustrated in Figure 4.

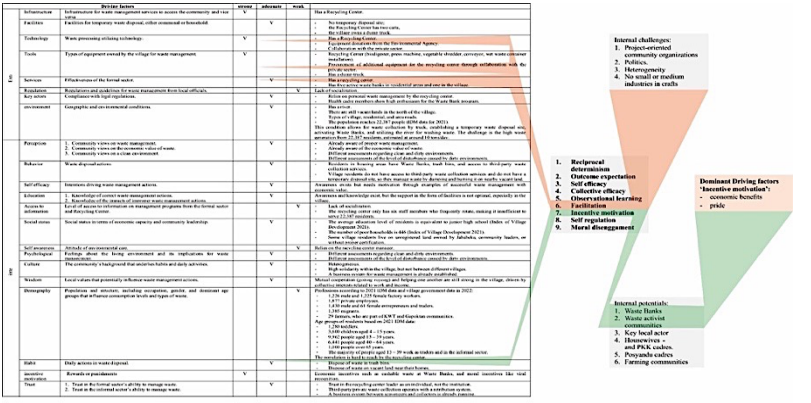

Figure 4. Diagram of dominant driving factors analysis
Source: developed by authors, 2024.

Issue Mapping

Discussions with three experts, including both practitioners and academics, revealed eight key waste management issues based on the data collected in Mekarmukti, Bekasi. These issues, identified through expert analysis, are presented in Figure 5. The mapping results reveal that illegal dumping is linked to community waste disposal practices and insufficient transportation, which hampers the transfer of waste to the Recycling Center. Improper disposal is attributed to difficulties residents face in managing waste, often resulting in burning as an alternative. Waste accumulation arises from inadequate disposal facilities and the inability of scavengers and waste banks to effectively collect residuals.

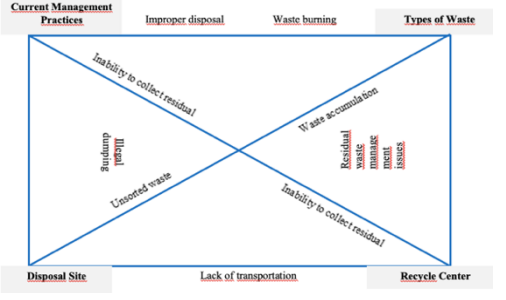

Figure 5. Issue mapping diagram
Source: developed by authors, 2024.

To further explore these issues, a workshop was held on November 18, 2023, at the Mekarmukti Recycling Center, Bekasi, and a discussion with the Tanjungbaru Waste Bank managers took place on May 15, 2024. These sessions aimed to continue problem mapping in collaboration with the community. The findings from these discussions indicate that the community's perception of waste influences the approach to addressing waste issues and solutions. In Mekarmukti, waste is seen primarily as a problem, leading to solutions focused on disposal or converting residuals into money.

Despite the Recycling Center's capacity to address these issues, management problems led to its closure. Conversely, in Tanjungbaru, waste is viewed as a potential resource, prompting solutions aimed at utilizing residuals. Economic drivers are seen as financial gains from the projects, while self-pride factors are perceived as moral benefits. Both types of incentives suggest that projects should be economically valuable and framed as community achievements.

Discussions with the managers of the Mekarmukti Recycling Center and the Tanjungbaru Waste Bank, along with data on the types of waste processed at these facilities, reveal that the community's understanding of residual waste includes any waste that has not yet been monetized. As of this writing, official data on the types and tonnages of residual waste is not available. However, data from waste inflows to the Mekarmukti Recycling Center allows for the categorization of residuals, even though their exact tonnages are not recorded. The residuals can be categorized as follows:

Table 1 –Residual

Plastic Residuals	Non-Plastic Residuals	Organic Residuals
Pigmented PET bottles Plastic bags (*keresek*) Packaging plastics and multilayer plastics Heavily damaged and dirty plastic drink bottles that affect their physical properties Burnt plastic drink bottles Adhesive and oily plastic drink bottles	- Used tires - Electronic waste - Diapers, cigarette butts, sanitary pads	Food scraps

The selected residuals are those that the community has not processed at any scale. Among these types of residual waste, some are present in negligible quantities and their supply cannot be reliably determined, such as heavily damaged, burnt, and oily plastic drink bottles, as well as non-plastic residuals. Pigmented PET bottles can still be monetized, but at a low price. Food scraps are already being converted into animal feed and compost. Therefore, the residuals chosen for further exploration are plastic bags and multilayer packaging plastics.

Figure 6. Workshop in Mekarmukti, November 2023, and discussion in Tanjungbaru, May 2024.
Source: Documented by the Researcher, 2024.

Implementation

The material exploration process is guided by the technical preferences of the community as derived from collected data. A significant challenge during the implementation phase was the closure of the Mekarmukti process were adapted for Tanjungbaru Village, which is in proximity to Mekarmukti and features an active Waste Bank with similar types of residual waste. However, the Waste Bank in Tanjungbaru has limitations, such as a lower investment capacity compared to the Recycling Center. The Tanjungbaru Waste Bank in Bekasi is equipped with a furnace used for destroying residual waste. The heat from this furnace was leveraged to process multilayer plastics and plastic bags, forming the basis for the material exploration session.

The following factors thus constrained the material exploration process:

1. Existing facilities at the Waste Bank/community.
2. There is a need for any additional equipment to be affordable for the community.

3. Minimizing extra activities, such as shredding, sorting, cleaning, or purifying materials, to prevent disruption to daily activities and avoid significant investment.

Laboratory-scale trials utilized an electric oven and a 10-ton hydraulic press. The objective was to process plastic waste without shredding, cleaning, or purifying the materials. The first phase focused on identifying the most effective technique for processing multilayer plastics and plastic bags through heat treatment and pressing, including determining the optimal heating duration and press pressure. Steel molds were used to produce boards with dimensions of 10 cm x 10 cm x 0.7 cm. The molded products were then cut with a saw to test the density and integrity of the processed materials. The ability to cut the material neatly without disintegration suggests potential for alternative treatments and shapes.

Table 2 – Experiment Process and Results for the First Stage

Experiment	Material		Heating		Press	Results	
	Type	Weight (g)	Temperature (°C)	Time (minutes)	Load (tons)	Weight (g)	Shape & Dimensions (mm)
I	Snack packaging and sachets	63	250°	90	1,5	52,5	Box: 8 x 8 x 0,7
II	Snack packaging and sachets	64	250°	40	3	59	Box: 10 x 10 x 0,7
III	Snack packaging and sachets	38,5	250°	60	3	77	Box: 10,3 x 10,3 x 0,7
	Plastic bags (not shredded)	39,5					
IV	Snack packaging, sachets, and plastic bags	100	250°	40	4	78	Box: 10 x 10 x 0,7

The sequence of the experiments is illustrated diagrammatically in Figure 7.

Figure 7. Sequence of material exploration processes for each experiment.
Source: Documented by the Researcher, 2024.

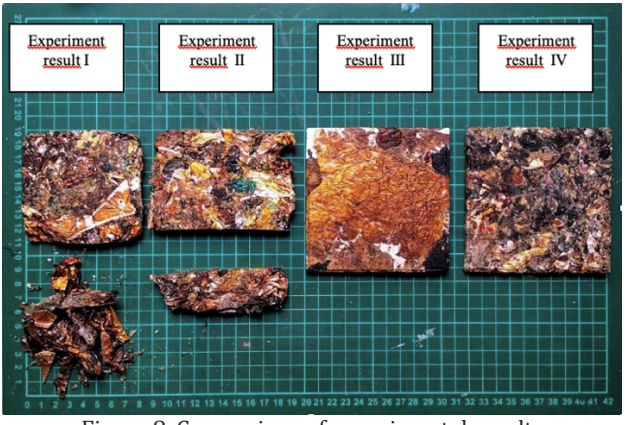

Figure 8. Comparison of experimental results
Source: Documented by the Researcher, 2024.

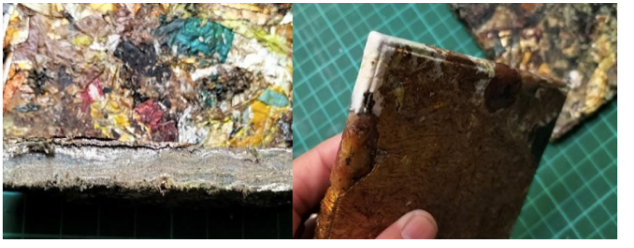

Figure 9. Details of cutting test results and achieved angles
Source: Documented by the Researcher, 2024.

Notes on the results of first stage experiments:

1. Plastic bags can serve as a binding agent, but aluminum foil from multilayer packaging cannot be melted.
2. The weight of materials after heating and pressing shows variable shrinkage. This shrinkage may be due to the waste materials not being cleaned, resulting in residual weight from packaging contents or water. Additionally, some material did not fully transfer into the mold as it adhered to the tray.
3. The best result in terms of material density and shape was achieved in Experiment III, which involved combining multilayer plastic packaging with plastic bags and heating for 60 minutes.

The second stage focused on exploring alternative shapes with curved surfaces, using the process from Experiment III as a model. The mold used was steel, producing a corrugated parquet shape with dimensions of 20 cm x 6.8 cm x 2 cm.

Figure 10. Mold design
Source: Designed and documented by the Researcher 2024.

Figure 11. Results of second-stage experiments with curved surface, including horizontal cuts made with a band saw.
Source: Documented by the Researcher, 2024.

Notes on the results of second stage experiments:
1. The mold results weigh approximately 200 grams.
2. To achieve uniform results, the material to be molded should exceed 200 grams. Excess material can be trimmed using a band saw.
3. The press machine pressure can be increased up to 5 tons.

Figure 12. Surface quality of molded results
Source: Documented by the Researcher, 2024.

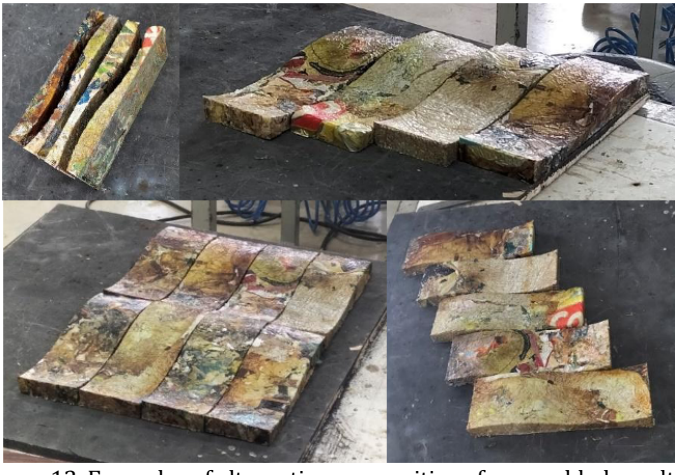

Figure 13. Examples of alternative compositions from molded results
Source: Documented by the Researcher, 2024.

As of this writing, design development is ongoing. The composition artwork from the results of the second-stage mold is being proposed. The quality of the surface and structure of the material, which can be cut with a saw, indicates its potential for creating functional products. These design development results will be taken to Desa Tanjungbaru for further production and community collaboration. The design remains under development at the time of writing.

Figure 14. Waste burning furnace at Tanjungbaru used for residual processing
Source: Documented by the Researcher, 2024.

DISCUSSION

Factors Driving Participation in Participatory Design

This study applies Bandura's social cognitive theory to examine the scale of participation and motivation in participatory design. This theory helps explain the dynamics of conflict, participation levels, and engagement within the community. The integration of social cognitive theory into participatory design can be summarized as follows:

1. Observational Learning: Communities can learn from case studies or examples of successful participatory design projects. Small-scale pilot projects that serve as observable models can encourage broader participation across other communities.
2. Self-Efficacy: The belief that individuals and groups can effectively address waste management issues strengthens their confidence to engage in the participatory design process.
3. Reciprocal Interaction: The interaction between behavior, environment, and cognitive processes encourages collaboration among community members, which fosters greater participation.

Operational framework:

1. Identify the dominant factors influencing community participation within participatory design. These factors can be categorized into the core elements of social cognitive theory: personal, environmental, and behavioral factors.
2. Collect data using surveys, interviews, focus group discussions, and field observations.
3. Analyze the data using an integrated framework that aligns these factors with social cognitive theory.

The data indicate that both the Mekarmukti and Tanjungbaru communities are more likely to participate when linked to economic incentives, such as increased income. However, the community also demonstrates pride and a desire to engage when the project highlights their involvement as a significant achievement. Participation in design projects often brings social recognition, which elevates the community's status. Success in these processes enhances self-esteem and confidence, motivating further involvement.

For example, during the Mekarmukti workshop, one participant noted that gaining social media "virality" could motivate greater community engagement. In this context, the Tanjungbaru community had already experienced such exposure, as the local waste bank manager demonstrated strong social media management skills. Therefore, participatory design activities should be structured to promote both community successes and economic benefits. Projects that offer commercial value and can be publicized as community achievements could be effective in fostering sustained participation in participatory design.

Design that Meets the Requirements

The participatory design activities in this research faced several challenges, including limited waste processing facilities, weak investment capacity, and community resistance to significant changes. The design solutions addressed these constraints by maximizing the use of existing community resources, avoiding costly investments or additional space requirements, and minimizing extra tasks such as sorting,

shredding, washing, or purifying materials. This resourceful approach reflects an understanding of local conditions and helps prevent barriers that could arise from the implementation of overly expensive or complex solutions. However, this strategy also presents limitations regarding scalability and long-term sustainability, as the existing equipment may become outdated or insufficient over time. For this reason, progressive yet affordable alternatives should be explored to address future needs.

It is also important that the solution incorporates minimal interventions that can be gradually implemented to enhance the quality of outcomes. While resistance to change is a factor, it should not be addressed merely by avoiding change altogether. There must be space for gradual education and mindset shifts, allowing the community to adopt new approaches without the pressure of immediate transformation. The participatory process in this context focuses not only on utilizing available facilities but also on involving the community in developing new ideas to support future sustainability. Although initial investments may be kept low, long-term planning and capacity building are crucial for sustained success.

From this perspective, participatory design projects, especially in the field of waste management, should be regarded as ongoing initiatives rather than short-term solutions. Designers must remain adaptable, viewing these efforts as long-term engagements that require continuous input and collaboration. Ultimately, the design solutions identified through participatory design seek to strike a balance by addressing the dominant factors that emerge throughout the process. This approach results in a design that is not only contextually appropriate and community-centered but also sustainable and aligned with local needs and capacities (Aulia et al., 2023).

Gaps Faced by Designers in Participatory Design Activities

This section reflects on the challenges encountered during the participatory design process and identifies gaps aligned with the study's objectives. It offers insights for improving

future design activities, particularly within the context of community engagement and participatory methodologies.

1. Fundamental differences in design and design methods.

   A key realization during the research was that design is not merely about producing products or technical solutions but about transforming social situations through human-centered processes. Designers often approach projects with a technical mindset, focusing on tangible outputs. However, participatory design emphasizes social dynamics, collective action, and long-term transformation. This shift requires designers to reassess their role. Are they facilitators of social change or experts controlling technical solutions? The distinction between these roles deeply influences how design is adopted and sustained by the community. A deeper exploration of how designers position themselves in participatory contexts—whether as enablers of change or as authoritative experts—must be pursued to ensure design methods are appropriately aligned with the social context.

2. The role of the community as key stakeholders.

   In participatory design, communities should be recognized as active agents with valuable local knowledge and lived experience, rather than passive recipients of solutions. Designers need to create environments that allow the community to explore, articulate, and test their own ideas. This repositions the designer's role as a catalyst for the creative process rather than its controller. Without a critical understanding of the social and economic hierarchies within the community, so-called "inclusive" participation can unintentionally exclude large segments of the population. Designers must ensure that diverse voices within the community are heard and integrated, especially those traditionally marginalized or excluded.

3. Designer bias and missteps in adopting design thinking.

   Designers may often arrive with preconceived solutions, assuming their proposals are optimal without fully understanding the community's needs, aspirations, and cultural context. This top-down approach overlooks the complexities of local social dynamics. Incorporating a more reflective, sociological lens enables designers to grasp the

intricate relationships, norms, and values that shape a community's acceptance of a solution. Techniques such as "deep empathy" and "rapid ethnography" should be integrated into the design process to better understand community mindsets. This shift from purely structured methods to a more nuanced understanding of the community's lived experience allows for more responsive and contextually appropriate design solutions.

4. Challenges in Increasing Community Motivation.

   Community motivation and participation are often driven by local interests and shaped by complex power relations. Designers must bridge the gap between various stakeholders, fostering trust and a shared sense of ownership over the design process. The social mapping conducted in this study proved useful as an analytical tool but needs to evolve into a collaborative process. By involving the community in "creating" their own social map, the design outcomes are more likely to reflect their actual social realities. This participatory approach not only strengthens community engagement but also empowers individuals to take an active role in shaping solutions that directly impact their lives.

CONCLUSION

A fundamental distinction exists between the conventional understanding of design and the process of designing within participatory frameworks. Participatory design is not merely about creating solutions but about transforming situations through an inclusive approach, acknowledging that systems cannot function effectively without considering the people embedded within them. At its core, participatory design involves stakeholders in co-creating solutions as part of a collaborative problem-solving process. The extent of participation may vary, but the focus remains on aligning the design process with collective community interests.

To maximize its potential, participatory design must be context-specific, directly engaging the community as the primary stakeholder. Designers often enter participatory processes with preconceived notions of what the solution

should be. However, it is the community that will ultimately adopt and live with these solutions. A significant gap arises from this divergence in perspectives—where designers, influenced by their expertise, may offer pre-conceived solutions that do not fully account for the social, cultural, and economic realities of the community. To bridge this gap, designers must develop a more profound understanding of these dynamics, moving beyond traditional design thinking to integrate sociological insights. This sociological approach, which examines the complex interplay of community relationships, values, and power structures, is a skill set that many designers may still lack but must cultivate to be effective in participatory contexts. For participatory design to thrive, designers must engage in comprehensive community mapping to understand the intricate relationships and social forces at play.

Addressing resistance to change requires a gradual, inclusive approach that empowers the community rather than imposing top-down solutions. While practical considerations—such as minimizing additional tasks like waste sorting—may enhance initial acceptance, long-term success hinges on strategies that raise awareness and foster sustainable community empowerment. Thus, it is imperative for designers to develop stronger social skills, facilitation capabilities, and cultural sensitivity to ensure that the design solutions not only gain acceptance but also genuinely reflect the community's long-term needs, values, and local potential. This shift in approach calls for a rethinking of design education, emphasizing the importance of social interaction, collaborative skills, and the ability to build trust through equal dialogue. Ultimately, the goal of participatory design is not only to produce effective solutions but to cultivate a sense of ownership and empowerment within the community, ensuring the sustainability of the outcomes.

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