

Research Article

Design Thinking Approach to Waste Management in Higher Education

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Abstract: Social problems, including environmental ones, are pressing issues across all levels of society, including university campuses. Universities should serve as role models in implementing poverty-alleviation concepts. However, the reality on the ground shows that environmental problems persist, including massive single-use plastic consumption, excessive paper use due to suboptimal digitalization, and poor waste management and sorting systems. These conditions, as experienced at the Faculty of Economics and Business (FEB) at Diponegoro University, negatively impact the environment and hinder campus efforts. The approaches used often fail to address the root causes of behavioral problems. This study aims to design and implement an effective, sustainable waste management solution in a university environment using the Design Thinking Approach. This research focuses on behavioral change, increasing awareness of desires, and designing a user-centred waste management system (students and staff). The results of this study are expected to be a prototype of an integrated waste management solution, including a recycling incentive system, a narrative-based awareness campaign, and an ergonomic, attractive redesign of waste sorting facilities. The main contribution of this research is to offer an innovative framework based on Design Thinking as an alternative approach to address environmental and social issues on campus, one that is transformative and grounded in user empathy, thereby encouraging sustainable behavioral changes among the academic community.

Keywords: Design Thinking, Waste Management, Campus Sustainability, Higher Education, Behavior Change.

I. INTRODUCTION

Social issues are a global phenomenon that have implications across the spectrum, including higher education. Problems arise when cultural or social components go out of phase, destabilizing group cohesiveness by dissipating the novel (Rogers, 2004 [1962]). In third-level education, lack of sustainability and waste management is an ever-growing issue (Kathryn Bruchmann, 20021). Universities should be taking a lead in sustainable development. If everything were perfect, institutions of higher education would be leaders in stewarding the planet and serving as an example to the world. But actual policies on most campuses leave much to be desired. High levels of consumption of single-use materials/items, especially plastic, and high use of paper, because digitalization is not yet at the optimal level. The university is an important area to study this phenomenon. For example, several reflections suggest that ready availability at inexpensive prices drives students to keep using single-use plastics. Yet despite campus sustainability initiatives, paper usage remains high on a daily basis. What's more, its ironic recycling at home and structured garbage disposal is being done on a minuscule scale! Graduation and environmental degradation 12 Gradual implementation of the lost waste management plan tends to promote indiscriminate dumping, leading to poor management of waste disposal, which in turn affects the campus environment as well as environs (Prince Nnonyelu, 2024). The hardest part to problem-solve is the behavioral change over time and creating systems that are intuitive. Simplest interventions that only target infrastructure (trash cans) and unidirectional law enforcement intervention (bans) are also likely to be limited in their efficacy as they fail to address the psychological processes and settings on which such behaviors depend. A framework is necessary that not only considers waste as a technical issue but also as both behavioral and systemic design concern (Siwaporn Tangwanichagapong, 2017).

A Design Thinking tool is suggested to handle these complex challenges. Design Thinking is a human-centred approach to innovation. It encompasses the human side, the technology aspect, as well as what makes business sense. The philosophy centres around empathy for the users: the students, faculty and staff. It reshapes problems in terms of its own, and provides original solutions. The solutions are then made into prototypes and repeatedly tested (Danielle Lake, 2024).. Applying the Design Thinking to the Innovative campus waste management ESD project can be designed appropriately based on regulations and needs in each university. This method seeks to encourage a shift in behavior by rewarding positive action, but 72 intuitively and at the same time encouraging long-term cost-effective sustainability of the program. Furthermore, this approach has the potential to encourage active participation from the academic community in the co-creation process(Gregory



Cogut, 2019). Based on the background and urgency that have been described, the problem formulation in this research is as follows:

- How can the Design Thinking framework be implemented to design an effective, sustainable, and user-centred waste management solution model in a higher education environment?
- What are the behavioral patterns and contextual factors underlying the high production of single-use plastic and paper waste in the university environment?

The main objectives of this research are as follows. First, analyze the root causes of behavior that produces high waste using the Empathize stage in Design Thinking. Next, design an innovative, sustainable campus waste management model through the Define and Ideate stages. Finally, develop a prototype and test its effectiveness in encouraging environmentally friendly behavior changes in higher education using the Prototype and Test stages.

II. LITERATURE REVIEW

A) Design Thinking Concept

Design Thinking is a systematic and practical innovation methodology for solving complex problems, particularly those rooted in human behavior and needs (complex problems). According to Brown (2008), Design Thinking is the use of design methods to integrate human needs, technological possibilities, and requirements for business success. The five key stages in Design Thinking are: (Carmen Vallis, 2021)

1. Empathize: Build a deep understanding of users (academics) and the waste problem from their perspective.
2. Define: Analyse empathy findings to formulate a clear and focused problem statement.
3. Ideate: Generate a variety of creative, radical, and unconventional solution ideas.
4. Prototype: Create a simple physical or conceptual representation of the solution for testing.
5. Test: Test the prototype with users to gain feedback and iterative improvements.

Design Thinking has gained recognition in its application to the public and social sectors because of its human-centred outcomes. In the service of sustainability, it allows designers to move beyond technical fixes and develop behavioral interventions. At the campus level, this might take the form of trash bins that are designed to be attractive and educational. And it might include digital rewards to give students an incentive to cut back on waste. This is important because being wasteful at the University level is a disciplinary issue. We are going to have to create solutions that literally change our habits (Kimberly McCoy, 2018).

B) Waste Management in Higher Education

A problem becomes social in nature when a segment of the population is regarded as undesirable and harmful. In a on-campus context, social issues will not only be how to make better living conditions or to have a better economy, but also involve sustainability and the quality of the environment. The lack of collective attention to the environmental implications of everyday campus life heralds a larger failure to embrace sustainability. Since universities comprise thousands of people and create a great amount of waste, the mismanagement of these residues is a significant social-environmental problem. (Sergey Bepalyy, 2024)

The notion of Green Campuses and Campus Sustainability is now an international one. Universities are more than teaching and research institutions; they should be living laboratories of sustainability. Engagement in sustainability encompasses three aspects: environmental (resource, waste and energy), economic (operational efficiency) and social (education, community). If this same amount of college waste is not handled properly, it's a signal that the successful and social aspects of these pillars cannot be fully recognized. (Ernest Baba Ali, 2020)

A waste management program is best when it has a hierarchy in theory: Reduce, Reuse, Recycle, and then finally dispose/process. Previous studies have highlighted reducing as the priority, which refers to waste prevention and minimisation at source. On campus, that translates to cutting back on single-use plastic and paper. If the first hierarchy (Reduce and Reuse) is not fulfilled, pressure will be placed on recycling and final disposal systems (W. Jeongsoo and Yu 2022).

Recycling programs are often dismal thanks to a lack of people who follow the rules. Studies show that despite a commitment to recycle, people often fail to follow through with action due to barriers including convenience (for example, distance from recycling facilities), cognitive (confusion about how to sort waste), and social norms (lack of peer support). Hence, any waste solutions must take into account behavioural and contextual design features supportive of environmentally friendly practices (Calvin Lakhan, 2017).

III. RESULTS AND DISCUSSION

A) Research Design

This research methodology adopts a case study approach enriched by integrating a design thinking framework in the

data collection stage. The application of design thinking specifically prioritizes the exploration and utilization of innovative ideas through concentration on three fundamental phases: the empathy stage, which aims to build a deep understanding of the user's perspective and experience; the problem formulation stage, which focuses on redefining the challenge more sharply and relevantly based on empathy findings; and the ideation stage, which encourages the creation of diverse creative solutions. Essentially, design thinking seeks to foster an ecosystem that supports creativity and collaboration. This allows the research team to explore more comprehensive and nuanced insights into the root of the problem, the characteristics and unique needs of the audience (or customers/end users), and the critical aspects that support the realization of sustainable development goals. Thus, combining case studies and design thinking collects data and stimulates human-centred and sustainable solutions. (Walter Leal Filho, 2024). This research design will follow the five-stage iterative cycle of Design Thinking, which includes: (Julia Von Thienen, 2017)

Table 1. Design Thinking Stages

Stages	The main purpose	Method of collecting data	Output
Empathize	Deeply understand users and the context of the waste problem.	Participatory Observation, In-depth Interviews (Students, Academic Staff & Lecturers)	Empathy Map, User Insights
Define	Analyze the findings and formulate a clear and focused problem statement.	Synthesizing Insights, Formulating Point of View (PoV).	Problem Statement, & How Might We (HMW) Questions.
Ideate	Produce various innovative and creative solution ideas.	Structured Brainstorming Sessions, Crazy Eights, Idea Matrix.	Various Solution Concepts.
Prototype	Create a simple prototype to test the solution concept.	Physical Mockup Creation, Service Flow Sketch, Simple Digitalization Scenario.	Solution Prototype (Low/Medium Fidelity Prototype).
Test	Test prototypes with real users to get feedback and improvements.	Usability Testing, Evaluation Interviews.	Feedback Data, Final Solution Iteration.

In this study, the testing phase was excluded because it focused solely on the creation of frameworks and policies.

B) Emphatize

State Legal Entity Universities (PTNBH), in particular, have such a large academic community with high mobility, which leads to a direct increase in single-use plastic use in these places. Therefore, the problem of campus plastic rubbish is being paid more and more attention to, and has posed a serious threat to sanitation, ecology and public health. This used plastic is found in many areas such as cafeterias, classrooms and public facilities. The situation is worsened by the absence of proper waste management plants, combined with the widespread use of disposable plastic items by students. The empathy mode of the Design Thinking framework is an essential starting point when we are getting to know what the needs and problems are. At this step, researchers attempt to get a sense of the problem from the community's perspective by investigating what issues they are confronting and how those social, emotional, and environmental structures have an effect on the lived experience of that community. Interviews were used to collect users' wishes and needs. In particular, major challenges associated with the universities are as follows (Saad Dahlawi, 2021):

- Excessive Plastic and Paper Usage: Students are continuing to use mostly plastic (plastic straws, wrap) in the cafeteria at Greenschools. Campuses themselves are a source of considerable waste, particularly paper, in their day-to-day operations and administration.
- Inefficient waste management bins: available trash receptacles are not efficiently maintained for disposal separation. Waste is also not always being discarded according to the right code or type, which results in contaminated or mixed waste as well.
- Low Student Awareness: Students do not always feel compelled to practice sustainable activities, such as taking their reusable containers and water bottles on the go as eco-friendly alternatives.

Findings from this initial phase of research identified three key barriers that hinder the successful implementation of sustainability practices and effective waste management in the campus environment:

Table 2. Problem Statement

No	Factors	Description
1	Low Student Participation and Awareness	The academic community still displays a reliance on single-use plastics due to convenience and affordability.
		Awareness of the role of digitalization in reducing paper consumption remains minimal.

		Energy-wasting behavior persists, characterized by the habit of forgetting to turn off electronic devices such as air conditioners or lights when a room is not in use.
2	Limited Infrastructure and Facilities	There is a lack of adequate waste sorting facilities, especially separate bins (organic and inorganic), in the faculty area.
3	Weaknesses in Regulation and Institutional Support	Universities lack clear and firm regulations regarding policies to reduce the use of single-use plastics.
		Some lecturers' academic policies still require paperwork to be submitted, contradicting digitalization efforts.
		Policy support for recycling programs and structured waste management remains minimal.

C) Define

Define is the design thinking framework's second stage. The aim is to give the problem a clear and coherent formulation. This is based on the information obtained in the first phase and empathy. The stage refers to studying, interpreting and making sense of the material. Decisions are based on a deeper insight into user needs and struggles. This process is convergent. All kind of information is omitted and concentrated upon the main problem for solution. (Roberto Verganti, 2021).

One approach in this step is to directly pose tough questions to stakeholders or members of the problem. The questions below probe further into needs, possibilities and constraints at the level of the context. The defining process also offers the researchers an explicit and more detailed understanding of the problem. This will bring the knowledge built in the first stage, that is, empathize, on par with reality. In this regard, scholars bridge between communities and schemes to a systematic understanding of the matter. These are the stepping stones to subsequent deeds." Based on the results of the community survey, some key findings in relation to awareness level towards organic waste are determined. (Khairul Hisyam Kamarudin, 2022).

Early interviews and surveys support the notion that there are remarkable barriers to incorporating environmental practices in higher education, even when students profess a strong inclination toward environmental values. This disconnect between awareness and immediate reaction is probably because of limited infrastructure, unenforced regulation and established habits hard to transform. From these findings, the objective of the defining phase is to determine central issues that need immediate attention to work towards a more sustainable campus. The key issues identified include:

- Ubiquity of Disposable Plastics: The widespread consumption and use of plastic is due to the lack (or inaccessibility) of convenient, simple alternatives.
- Lack of Waste Infrastructure: The dumping area or bins, specifically the availability of different baskets, are still lacking.
- Action and Awareness Discrepancy: The awareness of environmental issues has not been turned into feasible actions, like complete proper documentation digitization, or energy-saving operations.
- Academic Policy Obstacles: The printing policies of about 150 lecturers are still a major obstacle to reducing the amount of paper waste.
- Lax Rules and Lack of Motivations: There are no defined rules on campuses, as well as motivations for students to play an active role in environmental activities.

D) Ideate

Through a thorough review of campus environmental problems identified (from the "Definition" phase and verified through Prototyping), these strategies suggest multiple pragmatic, readily attainable, and sustainable solutions. These responses are developed to address two major goals: reducing environmental pressures and fostering pro-environmental behaviours among academia. The recommendations for the Green Campus Model (Campus Sustainability Solution Model) are categorized into three strategic pillars as follows:

a. Behavioral innovations and incentives (e.g., plastic-free days and waste bank programs).

Reducing the use of single-use plastics has been recognised as a significant behavioural issue. Hence, the introduction of a system: Plastic-Free Days. The purpose is for days or a couple of days in every month (Obviously on different dates) to be plastic-free, where the 'entire' academic community ' staff, qualified and support staff, students,' are encouraged to avoid using single-use plastic while on campus. This program will be funded with the support of:

- Refill Infrastructure: Refill stations should be installed on campuses at central locations where personnel can easily access, helping to eliminate the use of single-use plastic bottles.
- Incentivising a Pattern of Behavior: A reward-based incentive for students to bring their own food/drink containers would be put in place by providing either discounts or points that can be cashed in at the cafeteria.
- Create a digital waste bank to produce digitalized waste bank, in which students can donate plastic, paper or cans, which are recycled by them, and they will get some donation of currency in terms of points or meal tickets on a daily basis. The combination of these facilities and incentives is intended to inculcate new, sustainable patterns in higher education.

b. Improving Waste Management Effectiveness (Integrated Recycling Program)

Many waste management challenges on campus can be traced to narrow applications of recycling. An Integrated Recycling Program is recommended to transform waste into resources of economic value, and to achieve social awareness on responsible management of the same:

- Establishing a Campus Waste Bank: The robotization center will be an innovative collection site where students can convert waste (plastics, paper, cans) into points of interest in order to enhance participation motivation.
- Waste sorting system: There should be enough different bins for waste disposal to meet the needs of the campus. There are also four-compartment waste bins (Organic, Plastic, Paper, Metal) that allow the source-sorted disposal required for successful recycling.

c. Reducing Paper Waste Through Campus Digitization

Going digital is seen as part of a strategic plan toward better efficiency, less waste and smaller mountains of bad paper. Academic and administrative work is paper-intensive, leading to lots of wastage as well as poor data management/cataloguing. Proposed solutions include:

- Mandatory Electronic Assignments and Electronic Documents: Adopt a requirement that all student assignments be submitted through the campus LMS. This policy will reduce paper use and streamline the ability of faculty and staff to access their documents while maximising storage space.
- Training in digital competence: In order to facilitate a smooth and seamless running process, from analogue to digital consideration, the training of teachers/and students in the use of technology on campus. This training is designed to increase literacy and capacity in the effective use of digital platforms.

E) Prototyping

Once the core problem is clearly defined (Define) and innovative solution ideas are generated (Ideate), the next stage in the Design Thinking methodology is Prototyping. In the context of this research, Prototyping is implemented within a workflow to transform the best solution concept into a tangible, testable representation. This process is not intended to create a final product, but rather to visualize the work process and test the critical assumptions underlying the proposed solution. Three prototypes were designed and developed for testing:

a. Prototype 1 Reward-Based Recharge.

Table 3. Prototyping for Reward-Based Recharge

Process	Step 1: Drinking/Food Needs	Step 2: Action	Step 3: Verification and Incentives	Step 4: Sustainable Behavior
Frontstage	Students feel thirsty/hungry.	Students bring their own cups or containers to the Refill Station or Canteen.	Students check in (scan the QR code or show the container) to the system.	Students enjoy discounts/get rewards, and continue to bring their own containers.
Interaction Path (Service)	Cafeteria Notice/Promotion Board (Bring a Container, Get 10% Off)	Students refill water or buy food with their own containers.	Canteen/Refill Station staff validate and record transactions to the points system.	The campus provides more Refill Stations and attractive rewards.
Backstage			Sistem Digital Insentif (Bank Limbah Digital): Mencatat poin ke akun mahasiswa.	Sistem Poin melakukan update dan mengirim notifikasi reward yang tersedia.
Physical/Regulatory	Single-use plastic trash		Server/Database	The Facilities

Support	bins have been deliberately reduced in the canteen area.		processes the points and discounts awarded.	Unit manages the Refill Stations and enforces the Plastic Free Day Regulations.
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b. Prototype 2 Gamified Trash Station

Table 4. Prototyping for a Gamified Trash Station

Process	Step 1: Waste Collection	Step 2: Student Action	Step 3: Redemption and Value	Step 4: Recycling Cycle
Frontstage	Students have separated waste (Plastic, Paper, Cans)	Students bring the sorted waste to the Campus Waste Bank/Exchange Machine.	Students enter trash and get point notifications in the app..	Students use points to purchase food/drinks in the canteen..
Interaction Path (Service)	Education about waste sorting at the Gamified Waste Station.	Students interact with Waste Bank officers or Reverse Vending Machines (RVM).	The officer/machine verifies the type and weight of the waste, issues a digital voucher or points.	The canteen accepts payments using Bank Sampah digital points.
Backstage			Digital Waste Bank System: Convert waste weight into digital points, manage student point accounts.	Bagian Operasional Limbah Kampus mengambil dan mendistribusikan limbah yang terkumpul ke mitra daur ulang.
Physical/Regulatory Support	Installation of Gamification Trash Cans in all strategic areas.		Server/Database records the inventory of collected waste.	The Campus Team tracks and reports environmental impact (e.g., total plastic recycled).

c. For prototype 3 (Digital Nudge)

This was done by implementing leadership policies at the institution, issuing internal memos, and requiring lecturers to use the LMS for teaching and learning, including assignment collection.

IV. CONCLUSION

This research successfully applied the Design Thinking methodology to design a human-centred waste management intervention in a higher education setting. Through the iterative cycle of Empathize, Define, Ideate, Prototype, and Test, the core problem hindering sustainability on campus was clearly identified: a significant gap between high levels of environmental awareness among students and low levels of concrete action. This behavioral discrepancy is further accentuated by several contextual conditions, such as insufficient waste-sorting facilities, a strong dependence on single-use plastics and the absence of binding, supportive institutional regulations. Design Thinking helps the designers to get to the root cause of behavioral issues, rather than only making it a technical fix.

Through this iterative method, an Integrated Waste Management Solution Model was created to target behavioral and systemic obstacles simultaneously. The model is centered on three strategic areas: behavioral incentives, built environment change and campus policy enforcement. The motivation pillar attempts to motivate people with rewards that are related to new habits; the redesign pillar makes available services user-friendly and appealing, and the policy pillar creates a normative environment in which environmentally responsible actions make sense. Combining these three pillars is important for the long-term sustainability of the program beyond the timeframe of the study.

In particular, two proposed solutions, a Reward-Based Refill System and a Gamified Waste Disposal Station, were considered to show great potential to impact students' behaviour. The results of a prototype testing phase showed that adding digital rewards and engaging game design, engaging interaction of users were efficient to encourage participation and decrease misrouting. Yet the research also found that these models are heavily reliant on strong institutional support for long-term success. This involves a binding Zero-Paper policy, oriented at making paper waste at source impossible and seamlessly cross-linked systems that prevent behavioral incentives from getting lost in the sands of technical barriers.

V. REFERENCES

- [1] Calvin Lakhan. (2017). The garbage gospel: Using the theory of planned behavior to explain the role of religious institutions in affecting pro-environmental behavior among ethnic minorities. *The Journal of Environmental Education*.
- [2] Carmen Vallis, P. R. (2021). Introducing design thinking online to large business education courses for twenty-first-century learning. *Journal of University Teaching and Learning Practice*.
- [3] Danielle Lake (2024). Design Thinking in Higher Education: Opportunities and Challenges for Decolonized Learning. *Teaching and Learning Inquiry*.
- [4] Ernest Baba Ali,(2020). Towards environmental sustainability in Russia: evidence from green universities. *Heliyon*.
- [5] Gregory Cogut, (2019). Links between sustainability-related awareness and behaviour. *International Journal of Sustainability in Higher Education*.
- [6] Jeongsoo Yu, (2022). New Terahertz Wave Sorting Technology to Improve Plastic Containers and Packaging Waste Recycling in Japan. *Recycling*.
- [7] Julia Von Thienen, (2017). *Design Thinking in Higher Education*.
- [8] Kathryn Bruchmann, (2021). Social Comparison Information Influences Intentions to Reduce Single-Use Plastic Water Bottle Consumption. . *Frontiers in Psychology*.
- [9] Khairul Hisyam Kamarudin, (2022). Local Community Knowledge for Flood Resilience: A Case Study from East Coast Malaysia. *International Journal of Built Environment and Sustainability*.
- [10] Kimberly Mccoy, (2018). Nudging waste diversion at Western State Colorado University: application of behavioral insights. *International Journal of Sustainability in Higher Education*.
- [11] Magdalena Radulescu, (2024). Do Emission Trading Systems, Green Technology, and Environmental Governance Matter for Environmental Quality? Evidence from the European Union . *International Journal of Environmental Research*.
- [12] Prince Nnonyelu, (2024). Strategies for Enhancing Solid Waste Management Practices in Urban Secondary Schools in Developing Countries. *European Journal of Theoretical and Applied Sciences*.
- [13] Roberto Verganti, (2021). Design thinking: Critical analysis and future evolution. *Journal of Product Innovation Management*.
- [14] Saad Dahlawi, (2021). Assessment of solid waste management practice in the university campus. *International Journal of Sustainability in Higher Education*.
- [15] Sergey Bepalyy, (2024). Sustainable development awareness and integration in higher education: a comparative analysis of universities in Central Asia, South Caucasus and the EU. *Discover Sustainability*.
- [16] Siwaporn Tangwanichagapong, (2017). Greening of a campus through waste management initiatives. *International Journal of Sustainability in Higher Education*.
- [17] Walter Leal Filho, (2024). Design thinking for sustainable development: A bibliometric analysis and case study research. *Journal of Cleaner Production*.