Design Thinking: A Case Study on Mushroom Farming

Laurence[a], Agustina Christiani[a], Eric Jobiliong[a], Priskila Christine Rahayu[a], Rudy Vernando Silalahi[a]

[a]Industrial Engineering Department, Universitas Pelita Harapan, Lippo Karawaci Tangerang, Indonesia

ABSTRACT

In this design thinking project, observations were conducted on a white oyster mushroom cultivation business in Ciakar Village. This family-owned and self-managed business faces no issues with local demand, as confirmed through interviews with the owner, which indicates a stable target market. However, from the supply side, current production levels are insufficient to meet market demand. Business operations are largely conventional, leading to extended production times. A significant challenge is the manual preparation of mushroom growth media, which lengthens production time and limits harvest capacity. Using a human-centered design thinking approach, this project proposes a prototype solution aimed at improving production efficiency, providing a foundation for further development tailored to the business owner's needs.

Keywords − **Design Thinking, Oyster Mushroom**

INTRODUCTION

Self-contained cities are particularly attractive to newcomers. Typically functioning as satellite towns around capital cities, these cities are equipped with various facilities such as schools, hospitals, shopping centers, and more, designed to provide residents with convenient access to meet their needs. Consequently, essential services such as education, healthcare, and entertainment are readily available, reducing the need to travel to other locations. However, these residential complexes and visitor facilities require expansive areas, often surrounding long-established communities whose residents have inhabited the area for extended periods and engage in various livelihoods to sustain themselves.

This study focuses on Ciakar Village, situated near several satellite towns. Ciakar Village hosts a variety of small and medium-sized enterprises, including cricket farming, white oyster mushroom cultivation, catfish farming, and other similar businesses. Based on a preliminary survey conducted across these local businesses, mushroom cultivation was selected as the focus due to the village's air quality, temperature, and humidity, which are highly favorable for white oyster mushroom growth. This business holds significant potential to become a primary source of income for Ciakar Village, creating new employment opportunities for local residents.

This approach aligns with the United Nations' 17 Sustainable Development Goals, particularly Goal 8: Decent Work and Economic Growth, which promotes sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all. One of the measured indicators for SDG 8 is the target of achieving an annual growth rate of real GDP. Additionally, this study is aligned with SDG 12: Responsible Production and Consumption. A key target of SDG

12, specifically target 12.2, emphasizes sustainable management and efficient use of natural resources. This research examines the production aspect, closely observing the processes and various challenges faced by mushroom cultivation business owners.

LITERATURE REVIEW

The Design Thinking approach differs from traditional engineering and social sciences. At its core, design is a concept focused on creating something new, beginning with planning, discovery, and execution stages. This means that the design process requires a deep understanding of an object, whether it's a physical item or a human element, and finding ways to recognize and comprehend it fully. In this design phase, a designer translates the gathered data into a creation that conveys a message and represents the essence of the object (Cross, 1982). The design process includes various steps that allow for flexibility, free from the rigid frameworks often associated with scientific methods. As a result, there is no prescribed ideal technical guideline detailing each step, which provides designers with the freedom to adapt their approach as needed (Rowe, 1987).

Although there appears to be flexibility, the design process still requires cognitive aspects. There are two cognitive processes involved: refinement and adaptation. Refinement is a top-down approach, moving from general concepts to more specific details. Adaptation, on the other hand, is based on past experiences (R. E. Oxman & Oxman, 1992). Designers typically retain memories of past projects (Schon & Wiggins, 1992), which can influence their current work. Positive experiences, such as successful outcomes, as well as negative ones, like previous mistakes, are processed mentally and inform the selection and refinement stages of the design process. This internal reflection helps designers make more informed choices, leveraging past successes and learning from previous errors to enhance current design work.

In the design process, the final product results from iterative cycles aimed at achieving a progressively improved outcome. The final evaluation in design is inherently subjective, as assessments are qualitative in nature (Schon & Wiggins, 1992). Consequently, even if different individuals view the same object, their perspectives may vary. This evaluation includes judging whether the designer has effectively observed, interacted with, executed, and translated the object into something meaningful. In these initial stages, the designer requires a medium, such as paper or other materials, to convey what they see or imagine as an intermediary for their ideas.

To facilitate the implementation of a design thinking project, the team can use a concept map tool. This diagram consists of nodes that represent concept elements and links that illustrate the relationships between nodes. By using a concept map, additional information can be integrated, enhancing the team's collective knowledge. One such mapping method is the ICF model, which begins with an Issue (I) that identifies the problem, followed by proposing a Concept (C) as a solution, and then presenting the concrete Form (F) of the solution (R. Oxman, 2004). Using this type of visualization enables each team member to collaborate more easily on concepts and connections. Since design thinking was first popularized, various models have emerged, prompting questions about its definition and application across organizations. In dealing with complex

problems, often both the "what" (object, service, or system) and the "how" (the approach or method) are unknown. This unique mindset of designers has been adopted by organizations, allowing them to navigate unknown and complex conditions and create value through innovative solutions (Dorst, 2011). The success of creating value can be achieved collaboratively. Value co-creation is not a new concept, and its application can be observed in various areas of society. Human efforts to achieve goals more effectively and efficiently through collective innovation, ideas, and discoveries provide a tangible response to increasingly complex issues (Plattner, Meinel, & Leife, 2012).

In today's world, where competition between companies is intense, there is a need for individuals who can work with a wide range of skills. Design Thinking is a key skill that addresses this challenge, as products and services designed for and used by the public are crucial to a company's sustainability. Design Thinking requires various skills, including analysis, synthesis, and communication, to develop effective solutions that meet user needs and enhance the company's value (Razzouk & Shute, 2012). Although skills like quantitative analysis can now be supported by high-speed computers and advanced programming algorithms, human insight remains essential (Gobble, 2014). Additionally, human experience is crucial for understanding problems and needs before a product or service is launched in the market. This human element ensures that technological tools are guided by context, empathy, and a deep understanding of user needs, which are critical for creating solutions that genuinely resonate with end users.

METHODOLOGY

The stages of design thinking applied in this research include sense & sensibility, empathy, ideation, and prototyping (along with testing). The project was carried out up to the prototyping stage, followed by gathering feedback to refine the prototype. The primary principle in designing the prototype is to always keep the user's core needs in mind. Through the design thinking approach, the researchers hope to find effective and sustainable solutions to improve the efficiency, quality, and sustainability of oyster mushroom and worm cultivation businesses in Ciakar Village. The initial stage in the design thinking approach is the empathy phase. In design thinking, the ability to sense aligns with the "empathy" stage, where the team seeks to understand and experience the perspectives of users or customers. Meanwhile, "sensibility" refers to the capability to apply that understanding into effective and innovative solutions. Generally, the steps in the empathy phase include conducting interviews, building personas, creating persona need statements, summarizing insights, and finally formulating a problem statement based on the process.

Based on the interview with business owner, the next step is to develop a persona from the information gathered. In the context of Design Thinking, a "persona" refers to a fictional representation of the characteristics and needs of potential users identified in the research. Personas are created to help the design or innovation team better understand their target users, what they need, and how they might interact with a product or service. After completing the empathy stage, the next phase in the Design Thinking process is ideation. Ideation is a stage focused on generating creative ideas and innovative solutions to address specific problems or achieve certain goals. This

phase encourages the generation of as many ideas as possible without immediate evaluation or filtering. In this stage, the ideas generated are then grouped, selected to create a list of relevant ideas, and ultimately chosen as alternative solutions that can proceed to the next phase.

The next step is shortlisting *ideas*, which refers to the selection or screening process of ideas generated during the ideation stage. This is followed by selecting alternative solutions, rough sketch design of the prototype, and prototype creation. Based on feedback received, the next stage involves refining and developing the prototype further. The final step is to present and demonstrate the prototype to the business owner as the primary user and to hold an exhibition open to the public.

RESULTS

A design thinking project is a thematic and contextual project, tailored to the specific situation and conditions at the time (Braun & Clarke, 2022). The following is the result of an interview with the business owner regarding the background of establishing the business and the methods of oyster mushroom cultivation.

A. Historical Background & Production Process

The business owner operates an oyster mushroom and worm farming business. He is a family man, married with two children, one daughter and one son. The mushroom business began in 2009 when he was still an employee. However, the company he worked for went bankrupt in 2010, prompting him to start his mushroom business after being inspired by a TV program. Additionally, he learned from friends and visited oyster mushroom farms in other regions.

Initially, the business began by producing mushroom growing media at a different location than the current one. In 2016, the business moved to Ciakar Village, where the land is also well-suited for building mushroom houses or shelters. Currently, the production capacity is 10–20 kg, down from a previous 50–75 kg. To date, they have focused solely on oyster mushroom and worm cultivation, as both businesses demand significant time. The medium used for earthworm cultivation utilizes the leftover substrate from mushroom cultivation.

The mushroom production process consists of seven stages. The first stage is mixing ingredients for the mushroom culture medium, including sawdust, rice bran, ground corn, lime, and water. The second stage is fermentation, where the mixture is covered with a tarp and left to sit for one to two days. The third stage is packaging, which is time-consuming as only one mushroom substrate can be produced per minute. The business owner requires equipment to expedite mushroom growing medium production to increase mushroom output.

The fourth stage is sterilization, using a furnace for 6–7 hours to prevent mushroom cultivation medium contamination, which can lead to crop failure. The fifth stage is inoculating the mushroom spawn or mycelium under highly sterile conditions to prevent contamination. At this stage, a pipe is inserted into the mushroom base material, covered with newspaper, and secured with rubber bands. The sixth stage is incubation, where the media is left to grow for 30–45 days. The challenge at this stage is unstable weather, so the business owner uses a spray system to keep the shelter

humid and cool. The seventh stage is the generative phase, where the medium is harvested and maintained until it is no longer productive. Low-quality mushroom substrate can produce mushrooms 2–3 times, while high-quality ones yield 5–6 harvests. Once no longer productive, the spent mushroom growing medium is repurposed for worm farming.

The main challenges faced in this business are the manual process of preparing the mushroom substrate and unfavorable weather conditions. Additionally, the substrate mixture requires an accurate pH level, which can be adjusted by adding lime as needed. Another issue is capital limitations, which make it difficult for the business owner to purchase production tools. In terms of sales, oyster mushrooms are sold to the buyer at Rp 16,000 to Rp 20,000 per kg. Sales are conducted on a direct-purchase basis, where the quality of the oyster mushrooms must be high, indicated by a lack of reddish coloring, which would suggest high moisture content. If the quality is not sufficient, the business owner either distributes the mushrooms to neighbors or consumes them personally.

B. Persona, Need Statement and Insight

In this project, the persona developed based on the interview. Profile of the persona is the business owner and operator of the business. Here is the profile of the developed persona: Sunshine Aman, middle-aged man. The family status and size is married with two children. The occupation is Oyster mushroom cultivation business owner and mushroom farmer. Based on the interview, observation, and persona development, the top three needs of the persona can be summarized as follows:

1. I need alternative methods to improve the production process.
2. I need to increase production through other means besides hiring additional labor.
3. I need a better understanding of the environment to ensure optimal growth and development of the mushrooms.

Based on the three need statements above, the insights obtained from brainstorming are as follows:

1. They seek alternative approaches to improve the overall mushroom production process to meet demand.
2. They prefer not to hire additional workers to avoid labor costs and mitigate the risk that this decision may be less effective.
3. They aim to manipulate the environment to better support optimal mushroom growth.

C. Ideation and Shortlisted Idea

Based on the discussion results, 50 ideas were generated during the ideation phase. These ideas were then categorized into five clusters: process, collaboration, conditions, finance, and sustainability. Of the 50 ideas, 12 were selected for further consideration and potential development into the prototyping phase. Referring back to the interview findings, one current issue is the lengthy packaging process, which takes up to half a workday to produce mushroom medium. This process involves using a cut PVC pipe as a scoop with one hand, while the other hand holds the plastic substrate. To address this issue, the chosen solution idea is to develop a medium holder with an integrated filling function in a single tool, with the primary goal of optimizing the packaging process.

This initial solution development focuses on optimizing the filling of the medium into plastic to improve time efficiency and ergonomics. Therefore, from the collected ideas, the foundational concept for the prototype includes the use of a mushroom medium packaging machine with biodegradable plastic, a pressing tool to compact the mushroom base material, and a holder for the plastic mushroom substrate.

D. Prototyping and Refining

After creating the initial concept, the next step is to develop it into a prototype. This development involves analyzing the prototype design based on six aspects: the impact on users, persona profile, user needs identified from interviews, the value proposition offered by the prototype, available resources, and the infrastructure required for implementation.

The expected impact for users is that the tool should save time during the packaging process by being more efficient, reduce ergonomic risks, and be easy to use. Based on the persona profile created from interview findings, the persona dislikes time-consuming and costly activities. Therefore, the prototype aims to reduce production time without incurring high costs. In alignment with the business owner's needs, the prototype addresses two primary persona requirements: improving and enhancing the production process without adding extra labor.

The value offered by the prototype includes its construction from recycled materials and its low-cost design. The prototype features a sliding mechanism, allowing users to control the amount of mixture accurately. An additional benefit is its ergonomic value, as users no longer need to bend over for extended periods. Furthermore, this prototype is simple, does not require mechanical components, and does not depend on advanced technology.

For the improvement phase, a framework is used that examines five aspects, focusing on functionality. The guiding questions are structured using "What" to address each aspect. The first question targets technical aspects by testing what functions effectively ("what works?"). Next, the prototype is evaluated for potential improvements or enhancements to make it even more effective ("what could be better?"). Another essential question assesses which parts of the prototype are not functioning as intended ("what does not work?"). The fourth question explores additional or new ideas ("what additional and new ideas?"), and the final question considers how well the solution aligns with the persona or other crucial aspects that should be considered to further refine the prototype ("what related essential questions?").

DISCUSSION

In this project, interviews were conducted with multiple people to get multiple shareholder perspective (Geissdoerfer, Bocken, & Hultink, 2016). However, for the persona development stage, the persona was created based on the interview with the business owner, while other interview data served as additional support to enrich the understanding of the business owner's life. A key aspect of the interview process was the business owner's willingness to share experiences and stories. Effective interviewing techniques and the interviewer's style are essential for creating a comfortable atmosphere that encourages open sharing. The team needed to prepare thoroughly, including crafting an opening question list, and assigning roles such as interviewer, documenter, and others.

In a design thinking project with members from diverse backgrounds, strong collaboration is essential. Each member needs to set aside personal biases, as only one prototype will be developed from the filtered ideas. This prototype, built based on user needs, serves a purpose despite its imperfections, that helps to open users' minds and broaden their perspective. Thus, if the project advances to the next phase of creating a finished product, the prototype will serve as a reference for further development. This is why continuous refinement of the prototype is necessary. Feedback for refinement is gathered from team members, external sources, and users.

An important takeaway from this project is the application of strategies to extend the product life cycle. Typically, a product life cycle begins with the extraction of raw materials from the earth, and after the consumption stage, the product often ends up as waste (Andrews, 2015). In this project, a unique aspect was discovered: the mushroom growing medium is reused for earthworm cultivation. Subsequently, the used earthworm medium is sold as plant soil. This approach effectively extends the product life cycle, utilizing organic materials, and allows the business owner to profit from secondary ventures, namely the sale of earthworms and plant soil.

CONCLUSION

Design thinking is an excellent project-based approach for learning. Students learn to work in multidisciplinary teams, each bringing unique skills gained through their studies. Design thinking, characterized by its focus on solving complex problems through a qualitative approach, is particularly beneficial for equipping students with technical backgrounds. The materials and tools used in the design thinking project are simple and can include recycled items or discarded materials. This approach aligns with SDG 12, which promotes sustainable production and consumption. The resulting prototype is made from leftover, eco-friendly materials, avoiding the use of new resources.

Additionally, those involved in a design thinking project gain valuable experience confronting real-world, complex issues. They will gain valuable experiences, such as understanding the workflow and production processes at a business site, learning about the challenges faced by business owners, and, importantly, developing empathy by experiencing the pain points that they encounter. The empathy stage is a crucial and foundational phase in the design thinking process (Elsbach & Stigliani, 2018). This hands-on exposure serves as a valuable asset for their future careers.

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