Validating Market Demand for 3D Design and Printing Services Using Design Thinking and Value Proposition Canvas: PopStudio Startup Case Study

Nila Sa'adah[1] , **Dana Azizah Rahmat**[2], **Hujjatullah Fazlurrahman** [3], **Ahmad Titis Bagus Nalendra**[4]

Digital Business Undergraduate Program, Universitas Negeri Surabaya, Jl. Ketintang, Ketintang Gayungan, Surabaya, Jawa Timur 60231, (031) 8280009

Email : nila.23023@mhs.unesa.ac.id[1], danarahmat@unesa.ac.id[2], hujjatullahfazlurrahman@unesa.ac.id[3], ahmad.23490@mhs.unesa.ac.id[4]

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Abstrak - This study aims to identify the initial market needs for 3D design and 3D printing services at the digital manufacturing startup PopStudio and to develop a value proposition that supports achieving problem-solution fit. The study employs a mixed-methods approach with a qualitative focus through an exploratory case study. Data were collected using purposive sampling of 34 potential respondents and two key informants through questionnaires, interviews, digital observations, and analysis of internal documents. Analysis was conducted by integrating Design Thinking, the Value Proposition Canvas (VPC), the Lotus Blossom Diagram, and the Now–How–Wow Matrix through the stages of Empathize, Define, Ideate, Prototype, and Test. The research findings indicate that customers need not only 3D printing services but also end-to-end solutions that include design consultation, previews and revisions, rapid prototyping, reverse engineering, replacement parts, on-demand production, and transparent, responsive service processes. The three priority customer segments identified include Personal Users/Custom Product, Business Owners/SMEs, and Functional Users. These findings demonstrate that a customer-centric approach helps digital manufacturing startups formulate more relevant value propositions, strengthen service differentiation, and support service development aligned with early-market needs.

Keywords - 3D Printing, Design Thinking, Value Proposition Canvas, digital manufacturing startup, Problem-Solution Fit

1. INTRODUCTION

The transformation toward digital manufacturing is one of the key factors in enhancing the competitiveness of Indonesia's industrial sector. The Central Statistics Agency (BPS) recorded Indonesia's economic growth at 5.11% in 2025, rising to 5.61% (year-on-year) in the first quarter of 2026 [1], [2]. During the same period, the manufacturing sector contributed 17.39% to the national Gross Domestic Product (GDP) [3], demonstrating its role in driving innovation and economic growth. One of the technologies emerging in this transformation is Additive Manufacturing (AM), or 3D printing, which supports rapid prototyping, mass customization, on-demand manufacturing, and the flexible and efficient production of replacement parts [4], [5]. However, the successful implementation of this technology depends not only on technical capabilities but also on a company's ability to understand customer needs and build a value proposition that aligns with the market.

Previous research has shown that the adoption of AM still faces various challenges, such as limitations in 3D design capabilities, high initial investment, material selection, print quality, and business model readiness [4], [6]. In addition, 3D printing service customers are increasingly considering aspects of the service experience such as design consultation, cost transparency, flexibility for revisions, and quality assurance rather than just price [6]. To address these needs, prior research has begun to develop customer-centric approaches. Holzmann et al. [7] demonstrated that the success of AM-based businesses is influenced by the ability to develop

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business models and value propositions that align with market needs. Asiva et al. [8]demonstrated the effectiveness of Design Thinking in identifying user needs, while Ruhiyat et al. [9]explained that the Value Proposition Canvas (VPC) can map customer jobs, pains, and gains as the foundation for developing a value proposition. Nevertheless, research related to AM still largely focuses on technological aspects, production processes, materials, or business model development in isolation. Research explaining how empirical customer data is used to validate the market needs of digital manufacturing startups particularly during the problem-solution fit stage remains limited. This gap is significant because early-stage digital manufacturing startups typically face resource constraints, demand uncertainty, and the risk of developing services based on internal assumptions. These conditions can lead to market misfit, low customer acceptance, and even commercial failure. Therefore, a market validation framework based on empirical customer evidence is needed one capable of linking user need identification, value proposition formulation, and service development prioritization. These challenges were also observed at PopStudio, an incubator-based startup providing 3D design and 3D printing services. Based on observations, interviews, questionnaires, analysis of customer interactions, and business incubation workbook documents, it was found that potential customers struggle to translate their ideas into production-ready three-dimensional designs. Additionally, customers require services that include design consultation, price transparency, flexibility without minimum order requirements, and the ability to preview and revise designs before production. These findings indicate that customer needs are not only focused on the final product but also on a service experience that can reduce uncertainty during the product development process.

Unlike previous studies, which generally examined technology, business models, or customer needs separately, this study focuses on translating empirical customer evidence into an integrated market validation process. This study does not claim novelty in the methods used, as Design Thinking, VPC, the Lotus Blossom Diagram, and the Now–How–Wow Matrix have been widely applied previously. The main contribution of this study lies in its empirical findings, which yield a best-practice framework for validating market needs for on-demand manufacturing-based startups. Through the PopStudio case study, this research demonstrates how customer data is translated into the identification of market needs, the mapping of customer jobs, pains, and gains, the formulation of a value proposition, and the prioritization of service development. This framework has the potential to serve as a blueprint for digital manufacturing startups in developing countries with similar characteristics, such as limited resources, on-demand production, and uncertainty regarding customer needs in the early stages of business. Although developed through the PopStudio case study, this framework is not intended to be universally generalized but can be adapted by other digital manufacturing startups with comparable operational conditions and market readiness challenges. Thus, this study provides empirical knowledge that is not only relevant to PopStudio but also valuable to other digital manufacturing startups facing similar market validation gaps. Based on these conditions, this study addresses the following research questions: (1) What are the characteristics of the market needs for 3D design and 3D printing services at PopStudio? (2) What are the most dominant customer jobs, pains, and gains based on customer data? (3) What value proposition is most suitable for meeting customer needs? (4) Which services should be prioritized for development based on the results of the market needs analysis? This study aims to validate the market needs for 3D design and 3D printing services at PopStudio, identify customer jobs, pains, and gains, formulate an appropriate value proposition, and determine service development priorities to achieve problem-solution fit. From a theoretical perspective, this study contributes to research on startup market validation, customer-centric manufacturing, and problem-solution fit through the development of a framework based on empirical customer evidence. Practically, failure andch can serve as a reference for digital manufacturing startups, business incubators, and industry players in conducting market validation, formulating more targeted value propositions, reducing the risk of service development failure, and increasing the chances of success for on-demand manufacturing-based startups in developing countries.

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2. LITERATURE REVIEW

Manufacturing Process

Additive Manufacturing (AM), or 3D printing, is a manufacturing technology that produces three-dimensional objects by gradually adding material based on a digital model. Unlike subtractive manufacturing, which shapes products by removing material, and forming, which shapes material without significant addition or removal, AM offers advantages in design flexibility, material efficiency, and the ability to produce complex geometries [10]. AM technology supports various modern manufacturing needs, such as rapid prototyping, mass customization, on-demand manufacturing, and the production of replacement parts in small quantities without requiring high tooling cost. Its ability to facilitate rapid iteration makes AM particularly relevant for digital manufacturing startups, as it enables the development of a Minimum Viable Product (MVP) and the validation of customer needs more effectively. A comparison of the characteristics of Additive Manufacturing, Subtractive Manufacturing, and Forming is shown in Table 1.

Table 1 Comparison of Additive, Subtractive, and Forming

Aspect	Additive Manufac-turing	Subtractive Manufac-turing	Forming
Basic Principles	Adding material layer by layer	Creates materials from solid blocks	Shaping material without adding or removing material
Process Example	3D printing, SLS, DMLS	CNC Milling, Turning, Drilling	Casting, Forging, Stamping
Design Complexity	Very high	Medium	Low to medium
Material Waste	Very low	High	Low
Tooling Costs	Not required	Medium	Very high
Suitable for Needs	Small batches, prototypes, custom products	Precision, high, medium volume	Very high volume
Mass Production Speed	Slow	Medium	Very fast
Design Flexibility	Very flexible	Limited	Very limited

Based on Table 1, AM excels in design flexibility, material efficiency, and the ability to produce specialized products, whereas conventional methods are better suited for high-precision requirements and mass production [10], [11]. However, the implementation of AM still faces challenges in the form of material limitations, print quality, 3D design capabilities, production speed, and business model readiness (Attaran, 2017). Therefore, the success of AM-based services depends not only on technology but also on the ability to understand customer needs and create an appropriate value proposition.

Design Thinking

Design Thinking is a user-centered approach to innovation used to understand customers' needs, problems, experiences, and expectations before developing solutions [12], [13]. This approach helps reduce uncertainty in the innovation process through problem exploration, idea generation, prototyping, and solution testing.

According to the Stanford d.school and IDEO, Design Thinking consists of five main stages: Empathize, Define, Ideate, Prototype, and Test.

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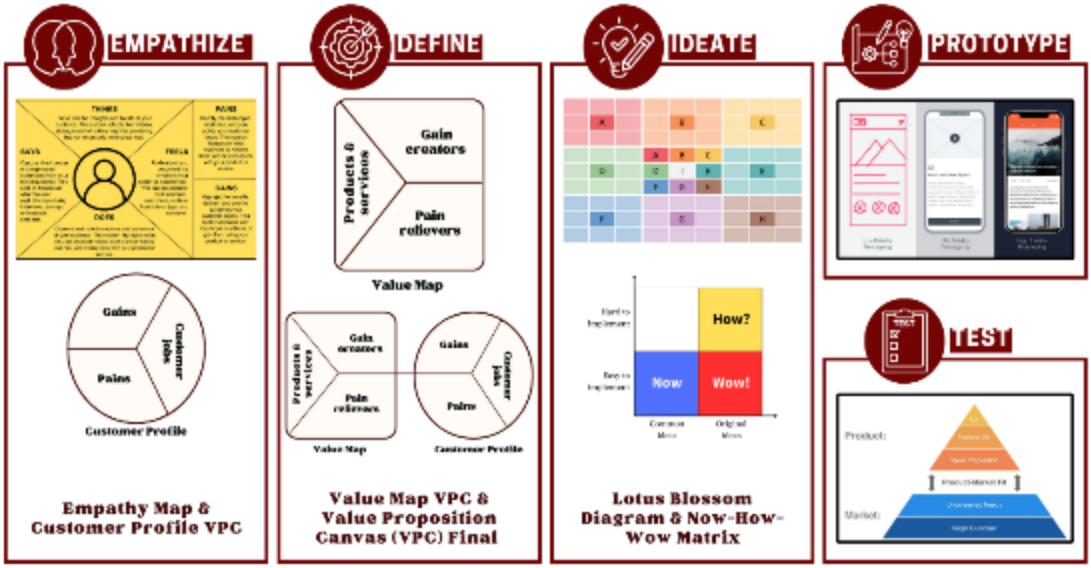

Figure 1 Design Thinking Flowchart Diagram

Based on Figure 1, the Empathize stage is used to understand user experiences and needs; Define is used to formulate the main problem; Ideate is used to generate alternative solutions; Prototype is used to create an initial solution design; and Test is used to obtain user feedback as a basis for refining the solution. In this study, Design Thinking was used as the primary framework for understanding the needs of customers of PopStudio's 3D design and 3D printing services.

Value Proposition Canvas

The Value Proposition Canvas (VPC) is a strategic tool used to understand the relationship between customer needs and the value offered by a product or service [14]. The VPC helps companies formulate relevant value propositions, thereby increasing the likelihood of achieving product-market fit.

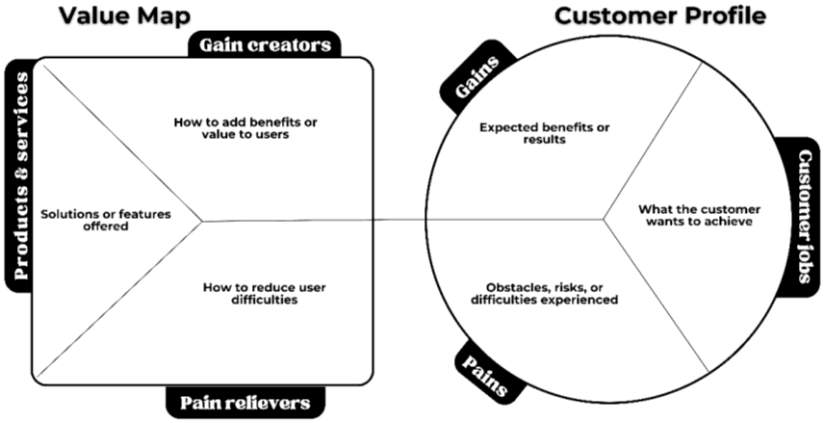

Figure 2 Value Proposition Canvas (VPC)

As shown in Figure 2, the VPC consists of two main components: the Customer Profile and the Value Map. Customer Profile includes Customer Jobs, Pains, and Gains. Customer Jobs describe customers' needs or goals; Pains indicate the obstacles customers face; and Gains explain the benefits customers expect from a product or service [14], [15]. Meanwhile, the Value Map

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consists of Products and Services, Pain Relievers, and Gain Creators. Products and Services describe the solutions whether products or services offered to address customer problems; Pain Relievers detail the specific solutions provided to alleviate these problems; and Gain Creators outline the added value delivered to customers [16]. By mapping these two sides, startups can design solutions that are truly relevant and provide clear added value to their customers. In this study, the VPC was used to translate the results of customer needs identification into value propositions for PopStudio's 3D design and 3D printing services.

Empathy Map

An Empathy Map is a tool used in the "Empathize" phase of Design Thinking to gain a deeper understanding of customers by mapping users' behaviors, thoughts, feelings, needs, and barriers [17], [18].

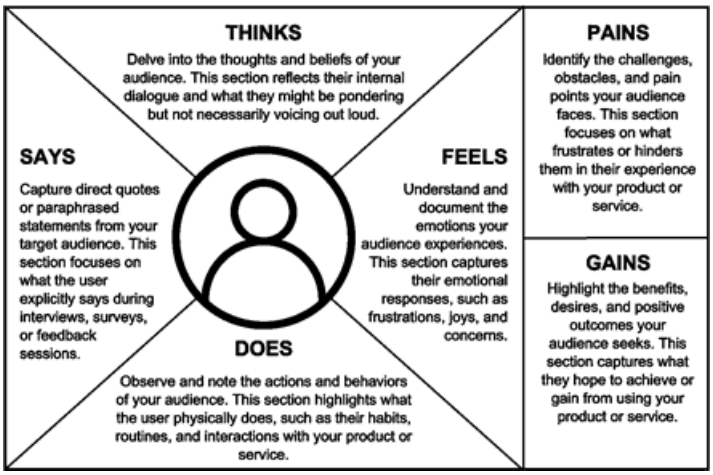

Figure 3 Empathy Map

As shown in Figure 3, this tool consists of six main elements: Thinks (what they think), Says (what they say), Does (what they do), Feels (what they feel), , as well as Pains (barriers) and Gains (customer expectations). This mapping provides a holistic view of customer behavior that is often not apparent from quantitative data alone. In the PopStudio study, the Empathy Map was used to understand the customer experience when using 3D printing services, such as difficulties in creating designs, cost uncertainty, the need for revisions, and expectations regarding service quality.

Lotus Blossom Diagram

The Lotus Blossom Diagram is an idea-generation method used in the "Ideate" phase of Design Thinking. This method helps expand solution alternatives by systematically breaking down a single main problem into various derivative ideas [19].

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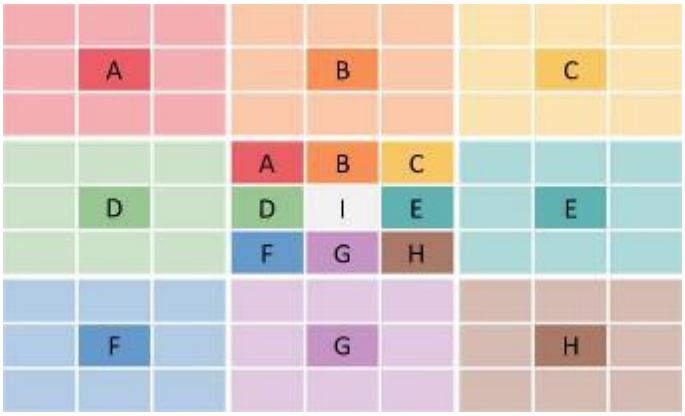

Figure 4 Lotus Blossom Diagram

As shown in Figure 4, the Lotus Blossom Diagram concept begins with the main problem at the center of the eight petals, which is then developed into several categories of ideas that can be further expanded into more specific solutions. This approach helps generate various innovation alternatives before determining the most relevant solution. In this study, the Lotus Blossom Diagram was used to explore alternatives for developing PopStudio's services based on previously identified customer needs.

Now How Wow Matrix

The Now-How-Wow Matrix is an idea evaluation method used to prioritize solutions based on two main aspects: the level of feasibility and the level of innovation [13].

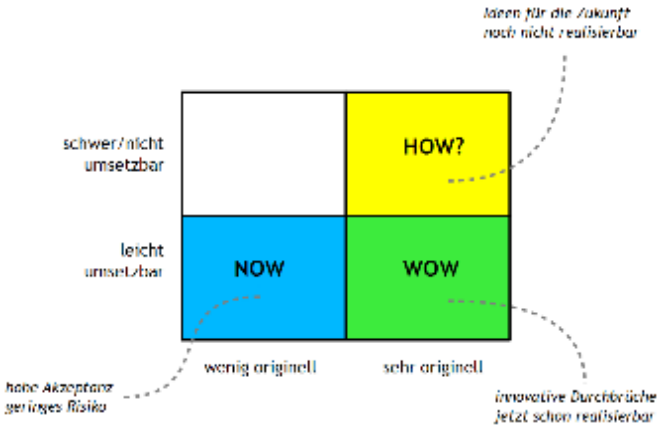

Figure 5 Now How Wow Matrix

As shown in Figure 5, the Now-How-Wow Matrix categorizes ideas into three groups. "Now" includes ideas that are easy to implement but have a low level of innovation, making them suitable for immediate implementation as short-term solutions (quick wins). "How" encompasses ideas with high innovation potential but require further development because their feasibility is still low. Meanwhile, "Wow" consists of ideas with both high levels of innovation and high feasibility, thus having the potential to provide a competitive advantage for the organization [13]. This tool helps startups effectively allocate resources between short-term solutions and long-term innovations. In this study, the Now-How-Wow Matrix was used to determine development priorities for PopStudio's services based on a balance between customer needs, the startup's resource capabilities, and the services' innovation potential.

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3. RESEARCH METHOD

This study employs a mixed-methods approach with a qualitative-descriptive focus through an exploratory case study design at PopStudio, a digital manufacturing startup that provides 3D design and 3D printing services. This approach was used to explore customers' initial needs, identify user problems, and formulate a service value proposition to support the achievement of problem-solution fit. This study does not aim to conduct statistical market validation or make generalizations about the population, but rather to understand patterns of customer needs within the specific context of PopStudio's service development.

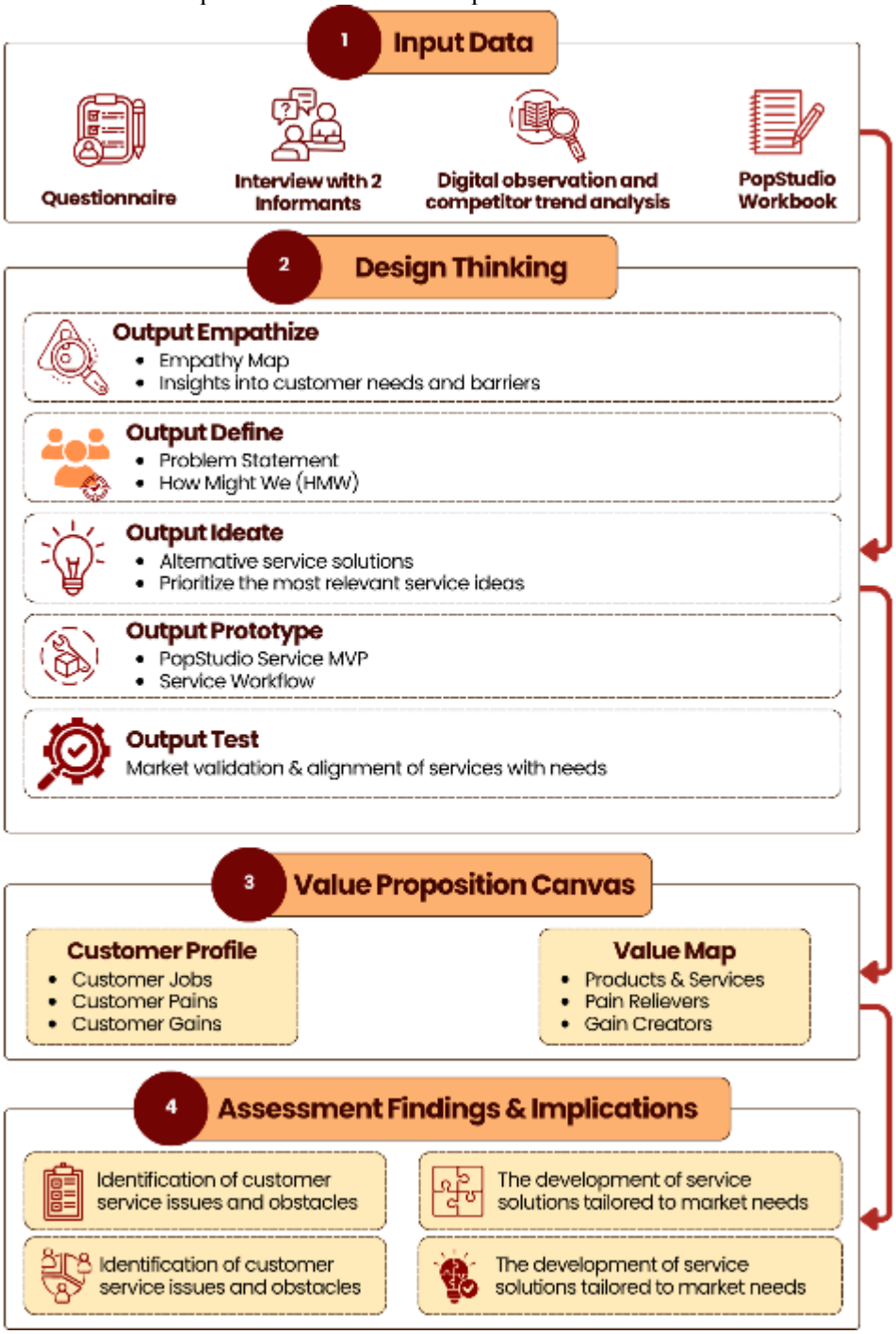

Figure 6 Research Flow Chart

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Based on Figure 6, the research framework integrates Design Thinking and the Value Proposition Canvas (VPC). Design Thinking is used as the primary approach through the five stages: Empathize, Define, Ideate, Prototype, and Test. The Empathize stage is conducted to identify customer needs, barriers, and expectations using an Empathy Map based on the results of questionnaires, interviews, digital observations, and internal documents. The Define stage is used to formulate the customer's problem statement and "How Might We" (HMW) questions. The Ideate stage uses the Lotus Blossom Diagram to generate alternative solutions and the Now–How–Wow Matrix to determine priorities based on the level of innovation and feasibility of implementation. The Prototype stage represents the initial service design (Minimum Viable Product/MVP), while the Test stage is used to evaluate customer feedback on the suitability of the developed solution.

Data collection was conducted using purposive sampling, involving 34 potential service users and 2 key informants. Respondents were selected based on their alignment with PopStudio's initial target market segments: Personal Users/Custom Product, Business Owners/SMEs, and Functional Users. The number of respondents was not intended to support statistical generalizations but rather to gain an in-depth understanding of customer jobs, pains, and gains in the PopStudio case study. Data sufficiency was determined based on data saturation, the point at which adding more respondents no longer yielded significant new patterns of needs and problems, particularly regarding 3D design challenges, consultation needs, cost transparency, revision needs, and production quality. Table 2 below details the characteristics of PopStudio respondents.

Table 2 Details on the Characteristics of PopStudio Respondents.

Segmen pengguna	Jumlah	Karakteristik Kebutuhan
Personal User / Custom Product	21	Requires personalized products, custom designs, design consultations, and a streamlined production process
Business Owner / SME	5	Needs product prototypes, display models, business product development, and a clear service workflow
Functional User	8	Requires specialized functional components that are difficult to obtain on the market, as well as designs with a certain level of precision
Total	34	

Respondent segmentation is determined based on service usage needs, not just on primary occupation, because some respondents who are students have needs related to business product development and functional components. This composition represents PopStudio's initial target market, which includes product personalization, MSME product development, and custom manufacturing needs. Table 3 summarizes the details of the instrument design and data collection techniques.

Table 3 Details of the Instrument Design and Data Collection Techniques

Characteristics	Category	Number
Age	18–22 years 23–27 years 28–31 years	25 5 4
Gender	Male Female	27 7
Employment Status	Student Employee Entrepreneur	25 4 5
Residence	Surabaya, Sidoarjo, and surrounding areas	34
Total		34

The majority of respondents are between the ages of 18 and 22 and are students. These characteristics align with PopStudio's initial target market, which includes young users, creative communities, users of custom products, and potential users of digital manufacturing services.

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Most respondents are familiar with or have tried 3D printing technology, but its use is still in the early stages, requiring support with design, consultation, and production guidance.

In-depth interviews were conducted with two key informants to validate the findings of the customer needs exploration. The first informant is a business owner in the furniture replacement parts sector with approximately two years of business experience who has used PopStudio's services 4–5 times because they needed specialized components not available on the market. The second informant is a custom product user who provided insights regarding service experience, design communication, and the quality of the final product. Table 4 below lists the research instruments and data sources.

Table 4 Research Instruments and Data Sources

Characteristics	Category	Number
Closed-Ended Questions (Online Questionnaire)	Knowledge of 3D printing, usage experience, design needs, preview, revisions, and service perceptions.	34 Respondents
Open-Ended Questions (Online Questionnaire)	Customer jobs, pain points, benefits, barriers, and customer expectations	34 Respondents
In-Depth Interviews	Concerns regarding the quality of physical printouts, the effectiveness of technical design communication, material selection, and transparency in production cost calculations.	2 Informants (Business Owner & Custom Product Consumer)
Observations & Internal Documents	Competitor interaction patterns, industry positioning strategies, and potential consumer profile data in incubation documents.	Digital Media, Competitors, & PopStudio Workbook

Data was analyzed descriptively through data reduction, identification of customer needs patterns, mapping of Customer Profiles and Value Maps on the VPC, and the establishment of service development priorities using the Now–How–Wow Matrix. The analysis results were used to develop a service development framework (best-practice framework) to understand initial market needs and support the development of an on-demand manufacturing-based startup within the PopStudio context.

4. RESULTS AND DISCUSSION

This chapter presents research findings based on the Design Thinking framework, integrated with the Value Proposition Canvas (VPC), the Lotus Blossom Diagram, and the Now–How–Wow Matrix. The analysis was conducted in stages to address the research questions regarding market needs, the identification of customer jobs, pains, and gains, the formulation of a value proposition, and the prioritization of 3D design and printing service development at PopStudio.

Preliminary Validation Results of Market Needs

The Empathize stage began with the distribution of a questionnaire to 34 respondents, revealing an interesting fact: 73% of respondents were already familiar with 3D printing services, but the majority had only used them once or twice. The main issue was not a lack of awareness, but rather a lack of independent design skills (73% of respondents admitted they could not create 3D designs). Additionally, 77% of respondents wanted a preview feature before printing, and 82% wanted a revision feature.

Based on these findings, it can be concluded that the main issue lies not in low levels of technological awareness, but rather in customer readiness to use digital manufacturing services to help customers turn ideas into 3D designs, provide a more intensive consultation process, and offer transparency through preview and revision features prior to production. The findings from the phase specifically the "Empathize" stage address the first objective of the research: identifying the characteristics of market demand for 3D design and printing services at PopStudio. These

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results also serve as the foundation for the "Define" stage, which involves identifying customer jobs, pains, and gains as the basis for developing a value proposition in the subsequent stage.

Findings from the "Empathize" Phase of the Empathy Map Process

Data from the Empathy Map shows that customers are interested in product personalization but are concerned about quality uncertainty, cost overruns due to revisions, and the complexity of technical processes. Through this tool, PopStudio was able to identify a strong correlation between consumers' real needs and the direction of solution development, as presented in Table 5 of the Empathy Map results below.

Table 5 Findings from the Empathy Map Mapping Stage

<table>
<tr><th colspan="3">Empathy Map</th></tr>
<tr><th colspan="2">Customer Profile</th><th rowspan="2">Pains</th></tr>
<tr><th>Thinks</th><th>Says</th></tr>
<tr><td>1. "I'm worried the result won't meet my expectations."
2. "I'm worried the process will be complicated if I have to explain the design."
3. "The production time will definitely take a long time."
4. "I hope they can create something unique and different from the rest."
5. "Hopefully the seller is patient, responsive, and communicative, especially during design revisions."
6. "Will the final product be precise, sturdy, and durable?"
7. "Is it expensive compared to buying a ready-made item?"
8. "If I keep placing large orders, will the price go up?"</td><td>1. "Can you customize it based on my photo or design?"
2. "Can you make it based on a reference image?"
3. "How long does the printing process take? I need it quickly."
4. "Can I order just one, or do I have to order in bulk?"
5. "Can I request design revisions?"
6. "Can the details be accurate? With a tolerance of 1 millimeter."
7. "What material is this made of? Can you use a different material?"</td><td>(No results yet; the results will be detailed in Table 2 Customer Profile Value Proposition Canvas Findings)</td></tr>
<tr><th>Feels</th><th>Does</th><th>Gains</th></tr>
<tr><td>1. "Excited to be able to create authentic products.
2. Confused because I've never ordered 3D printing before.
3. Worried that the results won't be precise or look like the design.
4. Afraid it will be expensive and the print will fail.
5. Happy to see the 3D design because it matches, but worried about the final finish.
6. Pleased that the product is finished and meets expectations."</td><td>1. "Orders are processed quickly.
2. Send image references from Pinterest or Reels, or even the actual physical item.
3. Compare prices with other services.
4. Request a preview or render before printing.
5. Negotiate price, turnaround time, and design revisions."</td><td>(No results yet; the results will be detailed in Table 2 Customer Profile Value Proposition Canvas Findings)</td></tr>
</table>

Based on Table 5, the results of the Empathy Map show that most potential customers want a 3D printing service that can translate raw ideas into print-ready 3D files. However, customers still have various concerns, such as a lack of understanding of the 3D printing process, uncertainty about print quality, production costs that are considered high, and the risk of product failure. These findings were then grouped into a Customer Profile consisting of Customer Jobs, Pains, and Gains, as shown in Table 6 (Customer Profile Value Proposition Canvas Findings).

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Table 6 Results of the Customer Profile Value Proposition Canvas

Customer Profile Value Proposition Canvas
Customer Jobs
1. Quickly creating product prototypes, particularly for replacement parts that are not available on the market. 2. Requires design and 3D printing services for college assignments or business product development. 3. Turning ideas, drawings, or physical objects into functional 3D-printed models. 4. Producing custom parts without having to invest in expensive machinery and operations. 5. Developing new products for business. 6. Looking for partners or suppliers who understand their needs. Creating figurines, souvenirs, merchandise, hobby-community toys, and participating in creative activities such as workshops, coloring sessions, or design exploration.
Pains
1. Replacement parts are not sold on the market, so users have difficulty finding replacement products that match the function and size. 2. Business owners struggle to develop new product ideas. 3. Unable to move to the mass production stage. 4. Business owners with limited funds for investing in production machinery. 5. Lack of 3D design skills, design files not yet ready for printing, and lack of understanding of suitable materials. 6. Fear of high costs due to repeated revisions. 7. No 24/7 design and printing customer service available for consultations (fast response). 8. Customers fear the final product won't meet expectations due to imprecise printing and poor quality. 9. Customers feel burdened by minimum order requirements.
Gain
1. A fast process from ideas to finished product. 2. Easy and guaranteed design revisions at any time (one-stop solution). 3. 24/7 design consultation that can break down their problems not just execution, but also feedback. 4. Recommendations for the right materials for the product's function. 5. A transparent process and pricing that matches the results. 6. Can request molds for mass production or be assisted with mass production featuring neat finishing (turnkey). 7. Find the right business partner. 8. Material options are not limited to filament materials 9. Access to creative activities such as coloring and workshops.

Based on the data from the Customer Profile in Table 6, the Customer Jobs analysis shows that customers use the service for prototyping, hard-to-find replacement parts, custom products, academic assignments, and business product development. The most dominant pain points include limited 3D design capabilities, limited production capital, uncertainty regarding print quality, uncontrolled revision costs, and burdensome minimum order requirements. Meanwhile, the Gains customers expect include a fast process, 24-hour consultation (revisions, material recommendations), price transparency, and high-quality results. These findings address the research objectives of identifying market needs and mapping customer jobs, pains, and gains as a foundation for the Define stage to formulate the main problem and develop a value proposition aligned with market needs.

Results of the Customer Problem Formulation in the Define Stage of the Value Map and Value Proposition Canvas

The Define phase aims to formulate the customers' main problems based on the results of the Empathy Map and Customer Profile from the previous phase. In this phase, customer needs data is analyzed using the Value Map in the Value Proposition Canvas (VPC), which consists of three components: Products & Services, Pain Relievers, and Gain Creators. Table 7 below presents the results of the formulation of the problems faced by customers.

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Table 7 Results of the Value Map in the Value Proposition Canvas

Value Map Value Proposition Canvas
Products & Services
1. (No results yet. The results will be detailed in the Ideate phase using the Lotus Blossom Diagram and Now How Wow Matrix)
Pain Relievers
1. Helps students and general users translate ideas and drawings into print-ready 3D files, even if they lack 3D design skills. 2. Provides a one-stop solution that allows customers to create custom products with no minimum order, reducing cost and process barriers. 3. 24-hour consultation service with quick responses that provides the right design and material selection solutions. 4. Ensures print quality through design previews and revisions before starting the printing process. 5. Providing replacement parts or custom parts according to the size and function desired by the user without having to buy a new, more expensive product.
Gain Creators
1. A structured and fast product manufacturing process, so customers can receive the final product on time. 2. Transparent pricing with clear calculations based on design complexity, materials used, and production time. 3. Hands-on learning and practical experience in 3D design through courses or workshops that enhance users' understanding of the design and production process. 4. Custom and unique products that meet customers' needs for merchandise, personal collections, or functional products not available on the market.

Based on the analysis in Table 7, it is evident that customers need a service capable of addressing the limitations of 3D design capabilities; furthermore, the service is expected to provide added value in the form of a fast process, transparent pricing, and products tailored to user needs. Subsequently, this problem statement was translated into four "How Might We" (HMW) questions to serve as a guide during the Ideate phase, namely:

1. How Might We provide replacement parts and custom products tailored to users' needs without requiring them to purchase a new unit?
2. How Might We develop a design-to-finished-product service for customers who lack 3D design capabilities, so they can obtain prototypes or custom products?
3. How Might We provide a real-time preview and process update system, so buyers feel confident and free from the fear of printing failures?
4. : How might we implement a transparent pricing system with no minimum order requirement, so customers can obtain authentic products at a predictable cost?

The findings from this phase serve as the foundation for the Ideate phase, where we design service solutions that align with market needs and address the research objectives related to developing a value proposition for customers.

The Ideation Process Using the Lotus Blossom Diagram

The Ideate phase is conducted to generate various alternative solutions based on the problem statement and the "How Might We" (HMW) questions formulated in the Define phase. The ideation process uses the Lotus Blossom Diagram to systematically develop solutions from a single main problem into several service alternatives that can be implemented by PopStudio. The mapping results are shown in Figure 7.

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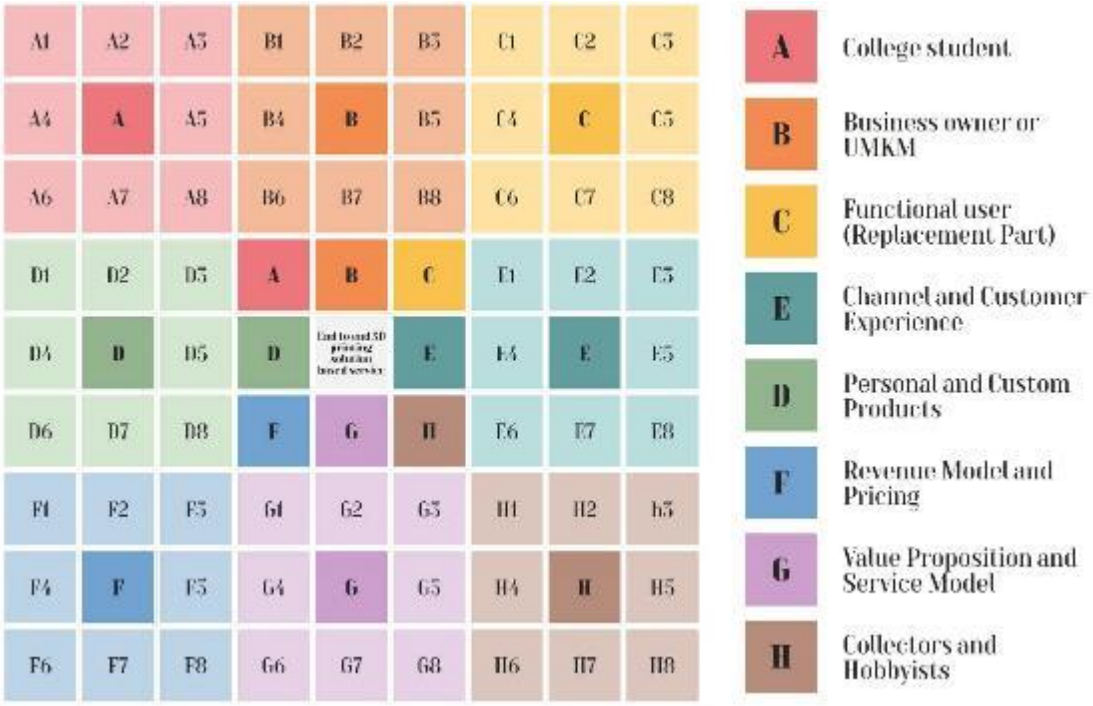

Figure 7 Results of Relevant Service Idea Alternatives Using the Lotus Blossom Diagram

Based on the mapping in Figure 7, the solution-based end-to-end 3D printing services yield eight main petals representing the focus of PopStudio's service development. Further details regarding the service development for each of these main petals are provided in Table 8.

Table 8 Lotus Blossom Diagram of Solution-Based End-to-End 3D Printing Services

Layanan end to end 3D printing berbasis solusi			
A	Students	E	Personal and Custom Products
B	Business Owner or SME	F	Revenue Model and Pricing
C	Functional User (Replacement Parts)	G	Value Proposition and Service Model
D	Channels and Customer Experience	H	Collectors and Hobbyists

A	**Mahasiswa**		
A1	Architectural model-making services based on a simple brief	A5	Basic 3D design education (workshop or micro-course)
A2	"Assignment Prototype" package (design + printing + finishing)	A6	Fast-track service for assignment deadlines
A3	Subscription plans for active students (discounts or bundles)	A7	Collaboration with universities or communities
A4	Marketplace with ready-to-edit design templates	A8	Integration with the needs of specific majors (architecture, engineering, product design)

B	**Business owner or UMKM**		
B1	Rapid prototyping services for new products	B5	Small-batch production for market testing
B2	"From Idea to Prototype" package for non-technical founders	B6	Integration into small business R&D processes
B3	Design iterations based on market feedback	B7	Product design consulting based on manufacturability
B4	Services for scaling up to larger-scale production	B8	White-label production for small brands

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Layanan end to end 3D printing berbasis solusi			
C	**Functional user (Replacement Part)**		
C1	Reverse engineering of damaged parts	C5	Material engineering for durability
C2	General parts database (printers, household appliances, light automotive)	C6	Obsolete spare parts (old products no longer available)
C3	Custom parts based on specific dimensions	C7	On-demand manufacturing
C4	Partnerships with technicians or repair shops	C8	Object scanning services

D	Channels and Customer Experience		
D1	Web-based platform for uploading ideas/files	D5	Social media for education and showcasing
D2	Chat-based consultation (fast response)	D6	Case study-based portfolio
D3	Visual dashboard for order tracking	D7	User community (user-generated design)
D4	Marketplace integration (Tokopedia, Shopee)	D8	Offline touchpoints

E	Personalized and Custom Product		
E1	Personalized souvenirs (for couples, communities, events) and niche community merchandise	E5	3D printing courses or training, from design to finishing
E2	Interactive creative experiences based on product personalization	E6	Limited-edition products and co-creation design with customers
E3	Custom products based on personal needs and self-expression	E7	A platform for uploading your own designs and collaborating with local creators
E4	Identity-based products (logos, characters) and gift customization based on personal stories	E8	Art studio for coloring 3D-printed products into personalized works of art

F	Revenue Model and Pricing		
F1	Pricing based on design complexity	F5	Freemium consultation → paid execution
F2	Pricing based on materials and print time	F6	Dynamic pricing for small batches
F3	Bundled packages (design + print)	F7	Add-on revenue (finishing, painting, assembly)
F4	Premium service (fast delivery / high detail)	F8	Subscription for businesses/students

G	Value Proposition and Service Model		
G1	End-to-end service (idea → design → preview → production)	G5	Pre-print preview (render/visual)
G2	No minimum order	G6	Limited design iterations with cost control
G3	Process transparency (progress tracking)	G7	Standard quality assurance
G4	Modular service (design only / print only)	G8	Fast response consultation

H	Collectors and Hobbyist		
H1	Custom action figures / miniatures	H5	Custom parts for kitbash/modification
H2	Replicas of rare items	H6	Additional painting services
H3	Diorama or display set	H7	High precision and detailed finishing
H4	Community-based pre-order	H8	Fan-based product (non-mass market)

Based on the mapping in Table 8, the Lotus Blossom Diagram, the ideation process yielded eight service development groups: the student segment, business owners or MSMEs, functional users (replacement parts), channels and customer experience, personalized and custom products, revenue models and pricing, value propositions and service models, and collectors and hobbyists. This categorization indicates that service development does not focus solely on production aspects

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but also encompasses customer segmentation, user experience, revenue models, and value propositions. Based on an evaluation of market needs and PopStudio's internal capabilities, three priority segments were identified: personal/custom products, business owners or SMEs, and functional users requiring replacement parts. For the personal/custom products segment, prioritized services include custom products, merchandise, co-creation design, and 3D printing-based creative activities. For the SME segment, the developed solutions include rapid prototyping services, product development mentoring, small-scale production, and design consulting. Meanwhile, in the functional user segment, service options focus on reverse engineering, custom part fabrication, replacement parts, and on-demand manufacturing services.

These findings address the research objective of formulating relevant value propositions and service strategies based on customer needs. Next, all of these service alternatives were evaluated in the subsequent stage using the Now–How–Wow Matrix to determine implementation priorities based on their level of innovation and feasibility.

Ideation Process Using the Now How Wow Matrix

The next step is to evaluate the various service alternatives identified through the Lotus Blossom Diagram, this time using the Now–How–Wow Matrix framework. This evaluation focuses on two main criteria: the level of feasibility and the innovation impact, with the aim of determining development priorities for PopStudio.

The mapping results showed that most of PopStudio's initial ideas fell into the "Now" category. This means that while these ideas are indeed easy to implement with current resources, their level of differentiation remains relatively low compared to competitors. Faced with this situation, the PopStudio team decided to pivot its service strategy. They developed new features that provide greater added value by gathering direct feedback from customers through questionnaires, interviews, and observations, as well as conducting in-depth analyses of competitors' services. Based on the insights gained from this process, PopStudio refined its features into an end-to-end service that allows customers to express their creativity more actively through activities such as coloring and workshops. This strategy was designed to shift PopStudio's service positioning from merely "Now" to "Wow" a service that is not only innovative but also worth adopting. Finally, all of these evaluation results were integrated into the Value Proposition Canvas as the primary foundation for restructuring PopStudio's business model.

Final Results of the Value Proposition Canvas and Alignment of Problems and Solutions

Based on the evaluation results using the Now–How–Wow Matrix, solution alternatives with the highest levels of innovation and feasibility were integrated into the Value Proposition Canvas (VPC). This process resulted in alignment between the Customer Profile (customer jobs, pains, and gains) and the Value Map (products and services, pain relievers, and gain creators), ensuring that the developed services meet user needs. A summary of the mapping results is shown in Table 9.

Table 9 Final Value Proposition Canvas

Value Proposition Canvas	
Value Map	**Customer Profile**
Produk and services • Rapid prototyping and product development. • Reverse engineering and custom parts. • Database of common parts and obsolete spare parts. • On-demand manufacturing. • Gift customization and limited-edition products. • 3D design consultation and revision	**Customer Jobs** • Customers who want ideas or sketches converted into print-ready 3D models. • Business owners who are developing new products without investing in machinery. • Functional users who need replacement parts or custom functional components.

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Value Proposition Canvas	
Value Map	**Customer Profile**
• Training and creative experience.	• Personal users and communities who require customized products in small quantities • Customers who want to learn 3D design and printing through practical activities.
Pains Relievers	**Pain**
• General users receive end-to-end design assistance from concept to production. • Business owners receive affordable prototyping without purchasing equipment. • Functional users receive custom parts based on dimensions or samples. • Customers receive transparent pricing, consultation, material recommendations, and quality assurance. • Customers can order without minimum order quantity (MOQ).	• General users have limited 3D design skills and difficulty preparing printable files. • Business owners face high prototyping costs and limited production resources. • Functional users cannot find suitable replacement parts in the market. • Customers are uncertain about production costs, print quality, and service transparency. • Customers are constrained by minimum order requirements for custom products.
Gains Creator	**Gain**
• General users obtain a structured and transparent ordering process. • Business owners gain product development support from idea to prototype. • Functional users obtain accurate and durable custom components. • Personal users and communities receive highly personalized products. • Customer gain practical knowledge and creative experience in 3D printing.	• Customers expect a simple, responsive, and transparent service process. • Business owners seek reliable partners for product development. • Functional users expect replacement parts that meet functional and dimensional requirements. • Personal users and communities expect products that reflect their identity and preferences. Customers expect opportunities to learn and explore 3D printing creatively. •

Based on the reanalysis of the Value Proposition Canvas in Table 9, it is evident that PopStudio offers services including rapid prototyping, reverse engineering, custom part manufacturing, on-demand manufacturing, and custom products, along with additional services such as workshops and creative experience activities. All these services are supported by design consultation, previews and revisions prior to production, price transparency, and guidance from the design stage through to the finished product. The alignment between Pain Relievers and Customer Pains indicates that the developed services effectively address customers' key challenges, such as limited design capabilities, difficulty obtaining replacement parts, uncertainty regarding print quality, and a lack of transparency in processes and costs. On the other hand, the alignment between Gain Creators and Customer Gains shows that customers gain added value in the form of simpler processes, products tailored to their needs, more personalized service, and support in product development and learning about 3D printing technology. The final research results show that PopStudio's value proposition no longer focuses solely on providing 3D printing services but has evolved into an end-to-end 3D solution encompassing consultation, design, validation, production, and education. These findings address all research objectives: identifying market needs, mapping customer jobs, pains, and gains, formulating an appropriate value proposition, and prioritizing services based on innovation levels and feasibility of implementation. Overall, the integration of Design Thinking, the Value Proposition Canvas, the Lotus Blossom Diagram, and the Now–How–Wow Matrix produced a market validation model capable of ensuring alignment between customer needs and the solutions offered. This model provides practical insights for the development of digital manufacturing startups in designing services that are more customer-oriented, possess a competitive advantage, and support data-driven decision-making.

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Final Idea Clarification and Adjustment Using the the Now How Wow Matrix

After going through a series of processes to develop and review service alternatives in the Value Proposition Canvas, the next logical step is to evaluate priorities using the Now–How–Wow matrix. The results of the analysis were quite impressive: most of the refined services successfully fell into the "Wow" category. This indicates a significant level of innovation and added value, particularly regarding customer experience and service personalization. Based on these criteria, PopStudio focuses on four main pillars: Custom Products & Prototyping, Replacement Parts & Reverse Engineering, and Creative Experiences. This strategy encompasses custom product services with no minimum order requirements, a system for previewing and revising designs before production begins, in-depth technical consultations, the provision of replacement parts, and the development of creative services such as workshops, 3D printing training, and creative coloring activities. The selection of this strategy is based on its ability to address real challenges faced by customers, ranging from limited design capabilities and uncertainty regarding print results to difficulties in finding rare replacement parts. Furthermore, this strategy is designed to enhance the overall customer experience. This evaluation phase demonstrates that the prioritized services not only meet customers' basic needs but also hold strong potential to create a competitive advantage. Thus, the use of the Now–How–Wow matrix has proven effective in achieving the research objectives, namely determining service priorities based on the level of innovation and feasibility of implementation, as well as producing a service model that is more adaptive to market dynamics. These findings confirm that the selection process is not merely a matter of setting priorities, but also of ensuring that the chosen solutions are relevant to market needs and stand out in the face of competition.

5. CONCLUSION

This study successfully answered the research question and achieved its objectives, namely identifying initial market needs, mapping customer jobs, pains, and gains, and developing PopStudio's service value proposition through the integration of Design Thinking, the Value Proposition Canvas (VPC), the Lotus Blossom Diagram, and the Now–How–Wow Matrix. The results show that customer needs are not limited to 3D printing services but have evolved into a demand for end-to-end 3D solutions that include consultation, 3D design, rapid prototyping, reverse engineering, replacement parts, on-demand production, as well as transparent, responsive, and customer-oriented services. These findings support the problem-solution fit validation process and serve as the foundation for developing PopStudio's value proposition and service development priorities. In practical terms, this research provides a framework that digital manufacturing startups can use to identify customer needs, design customer-centric services, and systematically determine innovation priorities. Additionally, this research contributes to the achievement of SDG 8 (Decent Work and Economic Growth) by strengthening digital manufacturing-based entrepreneurship, SDG 9 (Industry, Innovation, and Infrastructure) through the use of additive manufacturing technology to support product innovation, and SDG 12 (Responsible Consumption and Production) through the implementation of the on-demand manufacturing concept, which has the potential to improve resource efficiency and reduce overproduction.

This study has several limitations. First, the study employed an exploratory case study design focused on a single startup; therefore, the results are not intended to be statistically generalized. Second, data were collected through purposive sampling involving 34 respondents and 2 key informants to explore initial market needs in the context of PopStudio. Third, the study has not evaluated the implementation of the service on a broader market scale, nor has it quantitatively analyzed aspects of financial viability, technology acceptance, and sustainability impacts. Future research is recommended to test the implementation of the service model across a more diverse population and industrial sectors to enhance the transferability of the findings. In addition, future research could evaluate customer satisfaction and loyalty, analyze the financial viability and

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profitability of the business model, measure user acceptance of the service, and examine the economic, environmental, and social impacts of implementing on-demand manufacturing. Quantitative or mixed methods approaches with a broader respondent base could also be used to strengthen the exploratory findings obtained in this study.

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