Strategic Development of 3D Printing Entrepreneurship Using SWOT–TOWS Analysis: A Case Study of the PopStudio Startup

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Received 9 June 2026; Revised 16 July 2016; Accepted 19 July 2026

Abstract - Indonesia's economic growth of 5.61% in Q1-2026 has accelerated digitalization in the creative industry, including 3D printing services. Despite its vast potential, the commercial adoption of digital manufacturing services like Pop Studio at the Business Incubator of Balai Diklat Industri Surabaya faces obstacles, namely low consumer 3D design literacy and the threat of price competition from competitors. This study aims to analyze the internal and external environment and formulate the optimal business development strategy for Pop Studio. Using a mixed-methods approach, primary data were collected through field observations, in-depth interviews, and questionnaires distributed to 36 target market respondents. The SWOT matrix mapping shows that Pop Studio has a strong competitive advantage in end-to-end solutions and functional spare part reverse engineering. The TOWS matrix formulation yields Strength-Opportunity (SO) strategies as the main priority, including providing end-to-end solutions, addressing industrial prototyping (jig & fixture) using PETG material, and expanding the creative experience service (coloring studio). The results of this study are expected to serve as a strategic guide for digital manufacturing startup managers in building competitive advantages in the Industry 4.0 era.

Keywords - 3D Printing, Business Strategy, SWOT Analysis, TOWS Matrix, Business Incubator.

1. INTRODUCTION

Indonesia's economy is projected to grow by a solid 5.11% in 2025 [1] and rose again to 5.61% year-on-year in the first quarter of 2026 [2]. This stability serves as a catalyst for accelerating transformation in the creative industries and smart manufacturing sectors as they move toward the Industry 4.0 ecosystem. One of the most significant disruptions in manufacturing technology is Additive Manufacturing (AM), commercially known as 3D printing technology. 3D printing technology enables fast, precise, and highly customized production processes without the need for expensive initial molding costs. For Micro, Small, and Medium Enterprises (MSMEs), this technology offers rapid prototyping solutions that can significantly reduce product research and development costs.

To support the growth of technology-based startups, the government is optimizing the role of business incubators as platforms for acceleration. The Surabaya Industrial Training Center (BDI) Business Incubator is one such facility dedicated to fostering innovation in the digital manufacturing and creative industries sectors. Pop Studio is one of the startups incubated by this facility, focusing on providing 3D printing and 3D design services. This business unit targets a specific market segment, ranging from MSME players who need functional product prototypes and engineering practitioners seeking modified spare parts to the creative community. Operating within the BDI incubator ecosystem, Pop Studio has a significant opportunity to fully leverage advanced facilities and the ministry’s mentoring network. [3].

e-ISSN : 2356-2579 | p-ISSN : 1412-2693, DOI : 10.62411/tc.v25i3.16234

Although the market potential in the Surabaya area is very promising, there is an operational gap that is hindering Pop Studio's business growth. The results of an initial survey of 36 target market respondents indicate that approximately 73% of potential consumers have never actively used 3D printing services. This gap is driven by a major technical barrier, as 73% of respondents admitted they lack the ability or skills to operate 3D modeling software. Consequently, consumers struggle to translate their conceptual ideas into print-ready digital files, which fuels anxiety about the risk of print failures and escalating revision costs. This data indicates that the business model of conventional printing service providers, who merely act as machine operators, is no longer relevant; the market demands the integration of end-to-end design services.

In addition to the issue of consumer design literacy, Pop Studio also faces competition from regional rivals that employ a cost leadership strategy [4]. This threat of price competition from competitors is exacerbated by Pop Studio's internal weaknesses, which include high operational complexity and a production process that relies on a single expert designer (a bottleneck) [5]. These operational and market challenges call for the development of a systematic, academic, and practical business strategy [6]. Previous research on 3D printing in Indonesia has largely been dominated by studies of material mechanics and printing parameters. Literature examining business strategies, the governance of operational management in digital manufacturing services, and the tactical formulation of market positioning at the SME and incubator unit levels remains very limited. Therefore, this study offers novelty by integrating consumer behavior analysis with strategic management methods, namely the identification of SWOT factors and the TOWS matrix, to generate adaptive business policy directions for the 3D printing service industry.

Based on this background and these gaps, the research problem in this study focuses on mapping Pop Studio's internal and external conditions and how to formulate its strategies. The research questions posed are:

(1) What are the internal and external environmental conditions faced by Pop Studio?
(2) What does the SWOT analysis mapping of Pop Studio look like?
(3) What are the alternative business strategies for Pop Studio formulated through the TOWS matrix?

This study aims to identify the strengths, weaknesses, opportunities, and threats faced by the startup, map its competitive landscape, and develop actionable strategic recommendations. The theoretical benefit of this study is to provide a scientific contribution to the strategic management literature in the digital manufacturing sector. The practical benefit is to provide managerial guidance for the managers of Pop Studio and the BDI Surabaya Incubator in making decisions regarding expansion and operational efficiency.

2. LITERATURE REVIEW

A literature review is presented to establish a conceptual understanding of business strategies, competitive advantages, and the crucial role of SWOT analysis and the TOWS matrix in formulating managerial decisions. Additionally, this chapter elaborates on the concept of digital manufacturing, particularly 3D printing technology, and its relationship to improving service quality in startups. A review of relevant prior literature is included to highlight the urgency, novelty, and positioning of this research among existing scholarly works. All theoretical reviews are critically synthesized to ensure that the problem-solving approach used has a strong academic foundation and aligns with the current dynamics of the creative industry sector.

2.1. Business Strategy and Competitive Advantage

Business strategy is defined as a set of integrated and coordinated commitments and actions designed to leverage core competencies and achieve a competitive advantage. In Michael Porter's theory of competitive advantage, organizations can win in the marketplace

e-ISSN : 2356-2579 | p-ISSN : 1412-2693, DOI : 10.62411/tc.v25i3.16234

through two primary paths: cost leadership or differentiation. For micro-scale technology startups like Pop Studio, competing on low prices (cost leadership) is highly risky due to limited economies of scale. Therefore, a differentiation strategy that emphasizes service innovation, design problem-solving, and the creation of emotional value becomes a crucial foundation for building customer loyalty [4].

2.2. SWOT Analysis and TOWS Matrix Methods

SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) is a strategic planning tool used to evaluate an organization's position within its business environment [7]. Internal factors (Strengths and Weaknesses) are analyzed to identify human resource capabilities, technological availability, and operational process efficiency. Meanwhile, external factors (Opportunities and Threats) are explored through market dynamics, government regulations, consumer behavior, and competitor movements. After mapping these strategic factors, tactical formulations are developed using the TOWS Matrix [6]. The TOWS Matrix cross-references internal and external variables to generate policy alternatives that are adaptive to the dynamics of the digital manufacturing industry. Through this TOWS confrontation approach, Pop Studio can formulate four strategic quadrants, namely:

1. SO Strategy (Strength-Opportunity): Leveraging internal strengths to aggressively seize market opportunities.
2. WO Strategy (Weakness-Opportunity): Overcoming internal operational weaknesses by exploiting external opportunities.
3. ST Strategy (Strength-Threat): Optimizing internal strengths to mitigate the impact of business environment threats.
4. WT Strategy (Weakness-Threat): A defensive tactic aimed at minimizing internal weaknesses and avoiding external threats.

2.3. Digital Manufacturing and 3D Printing Services

Digital manufacturing is the integration of computer systems, data analytics, and three-dimensional modeling into the physical production process [8]. Under the umbrella of digital manufacturing, 3D printing or Additive Manufacturing technology plays a crucial role due to its ability to produce physical objects from CAD (Computer-Aided Design) files without requiring traditional molding. In a commercial context, the most commonly used thermoplastic polymer materials are Polylactic Acid (PLA) and Polyethylene Terephthalate Glycol (PETG) [9]. PLA is known for being environmentally friendly, easy to print, and ideal for aesthetically pleasing prototypes [10]. Meanwhile, PETG offers mechanical strength, elasticity, and high-temperature resistance, making it highly suitable for manufacturing functional industrial machine components (jigs and fixtures). Mastering these hybrid material variations is a critical prerequisite for enhancing the competitiveness of service providers

2.4. Research Rationale

The need for strategic engineering in Indonesia's additive manufacturing industry is critical, given the wide gap between advances in machine technical capabilities and business management readiness at the startup level. Most research published in indexed national and international journals remains confined to the domains of metallurgical analysis, mechanical testing of filaments, or the mechanical optimization of desktop 3D printer parameters. Consequently, vital aspects such as commercialization, market positioning, mitigation of regional price wars, and the integration of digital marketing strategies are often overlooked in the scientific literature [11]. Therefore, conducting strategic research that examines the business sustainability posture of 3D printing service providers has become an academic urgency that cannot be postponed, in order to fill the gap in references regarding digital engineering operations management. This in-depth investigation is expected to bridge the commercial

e-ISSN : 2356-2579 | p-ISSN : 1412-2693, DOI : 10.62411/tc.v25i3.16234

understanding of business actors so that they do not merely become 3D printer operators, but rather reliable technical advisors for industrial needs.

Practically, the urgency of this research is further reinforced by the high risk of operational failure and bankruptcy looming over startup micro, small, and medium enterprises (MSMEs) in the high-tech sector during their early years of establishment [5]. Business incubators such as the Surabaya Industrial Training Center require a strategic evaluation blueprint that is not merely descriptive but capable of providing prescriptive guidance ready for implementation by the incubated businesses (tenants) [3]. Without a comprehensive mapping of internal and external factors using SWOT and TOWS analysis, digital manufacturing startups like Pop Studio will be highly vulnerable to being overwhelmed by price aggression from large-scale mass-market players in the Greater Surabaya area [4]. Through the formulation of a sharp, integrative strategy, this research must be completed to safeguard the technology incubator's investment and ensure the sustainable acceleration of additive manufacturing-based creative economic growth in East Java. The final results of this study also have the potential to be replicated by other technology incubator managers in Indonesia who are nurturing similar micro-enterprises to secure long-term competitive advantages.

3. RESEARCH METHOD

This study employs a mixed-methods approach using a single-case study design of a descriptive-analytical nature. The use of this hybrid method is designed to obtain in-depth qualitative narratives on consumer and competitor behavior while also enabling the quantification of weights for strategic matrix calculations. The research subject focuses exclusively on Pop Studio's business strategy. Field research, observation, and data validation were conducted at the operational site of the Surabaya Industrial Training Center Business Incubator.

3.1. Data Analysis Techniques

The data analysis procedures in this study were systematically implemented through several integrated stages that complemented one another. The initial stage focused on collecting and reducing raw data derived from interviews, questionnaires, and field observations to filter out information relevant to the research variables. Subsequently, the condensed data were classified into internal environmental factors (strengths and weaknesses) and external environmental factors (opportunities and threats) as the primary foundation for developing the SWOT analysis. Once the strategic variables have been identified, the next step is to translate this descriptive matrix into more prescriptive policy formulations through the use of the TOWS matrix [6]. To conclude the analysis process, the feasibility of all generated tactical alternatives will be evaluated to ensure they can be realistically implemented in the pilot unit. This structured data analysis cycle, from upstream to downstream, is systematically visualized in Figure 1.

e-ISSN : 2356-2579 | p-ISSN : 1412-2693, DOI : 10.62411/tc.v25i3.16234

Figure 1. Research Workflow and Strategy Formulation Process

This workflow diagram illustrates a staged strategic formulation model divided into four sequential, interactive phases that influence one another in an upstream-to-downstream manner [11]. The first phase begins with a preparatory stage that combines problem identification, literature review, research design, and a comprehensive exploration of the startup's internal profile such as its vision, mission, and market objectives. The subsequent stages sequentially explore internal conditions in the second phase to extract strengths and weaknesses through digital media audits and internal data, which are then dynamically compared with the results of mapping external environmental opportunities and threats in the third phase. This series of processes culminates in the fourth phase, which formulates a synthesis of solutions in the form of strategic development recommendations, the design of short- to long-term tactical action plans, and an evaluation of academic and practical contributions to business sustainability. Through the implementation of this phased framework, the results of the analysis are no longer merely static and descriptive but are transformed into an adaptive and practical operational roadmap to accelerate the digital competitiveness of startups in the Industry 4.0 era.

3.2. Data Sources and Data Collection Methods

Primary and secondary data were collected using a rigorous triangulation approach to ensure the scientific validity of the study:

1. Questionnaire Distribution: A structured questionnaire utilizing a 5-point Likert scale was distributed digitally to 36 target respondents. The study employed a purposive sampling technique to ensure the selected participants accurately reflected the specific behaviors, needs, and operational constraints of Pop Studio's intended market. The inclusion criteria for the respondents were strictly defined based on several parameters. First, for the background and relationship criterion, participants must belong to specific target segments comprising engineering or design students, MSME operators, hobby collectors, or creative industry workers who represent prospective clients for Pop Studio. Second, for the location criterion, respondents must be domiciled or operate their businesses within the Greater Surabaya area, aligning with the startup's regional market focus. Third, for the age criterion, participants must be within the productive age demographic (18 to 45 years old) relevant to the creative and industrial sectors. Fourth,

e-ISSN : 2356-2579 | p-ISSN : 1412-2693, DOI : 10.62411/tc.v25i3.16234

for the experience and interest criterion, respondents must demonstrate a concrete interest in or prior experience with 3D printing services for prototyping or custom production, particularly those experiencing technical barriers in 3D modeling. This instrument was specifically designed to validate technical barriers to 3D design, price sensitivity, and the urgency for design mentoring services.

2. In-depth Interviews: Qualitative data collection was conducted through structured interviews with the three main founders of Pop Studio and a mentor from BDI Surabaya. The interviews focused on mitigating production bottlenecks, machine learning capabilities, and the efficacy of B2B penetration strategies.
3. Participatory Observation and Document Review: The researcher conducted embedded observation of the operational workflow of 3D printers at the incubator facility and reviewed internal documents from the Pop Studio Business Incubation Workbook, which contains 34 assignment modules for startup planning.

4. RESULTS AND DISCUSSION

The presentation of results and discussion is the most crucial stage in the structure of scientific research, aimed at distilling empirical data into analytical findings with prescriptive weight. Through a systematic analytical framework, raw facts regarding service constraints and the company's growth potential are directly confronted with the realities of industry competition in the field. This chapter presents the results of an in-depth exploration of Pop Studio's service profile, the identification of SWOT factors within Surabaya's manufacturing landscape, and a tactical breakdown of business strategy formulation using the TOWS matrix framework. The discussion outlined in this chapter does not merely describe the status quo (current state), but projects the managerial engineering required to capture dominance in the 3D printing manufacturing market.

4.1. Research Subject Profile

Pop Studio operates under the structural supervision of the BDI Surabaya Business Incubator [3]. By combining expertise in manufacturing engineering with digital creativity, Pop Studio distinguishes itself from commodity polymer printing vendors through three pillars of integrated services: prototype manufacturing for Business-to (B2B) and jig & fixture design, custom souvenir design engineering for B2C (Business-to-Consumer), and the organization of educational activities in the form of creative coloring experiences.

Based on data extracted from market questionnaires, it was found that 73% of potential users lack the skills to operate 3D design software (such as AutoCAD or Blender), making design services (3D modeling) from scratch the key to overcoming commercialization barriers. Furthermore, 82% of respondents stated that the availability of a revision phase and pre-print preview features is an absolute requirement to avoid anxiety regarding material losses [11]. This need conflicts with the nature of the main competitors in the Surabaya area (Sultan 3D Print and Kilat 3D Print), which focus solely on instant printing execution without consultation support (consultative barrier).

4.2. Market and Competitor Behavior Analysis

Based on the tabulation of questionnaire data from 36 target market respondents, it was confirmed that the majority (73%) of consumers are not yet proficient in using 3D modeling software; thus, the lack of design services from scratch among competitors serves as a significant barrier to entry for customers. A total of 77% of respondents stated the urgency of a digital preview before printing, and 82% strongly need the opportunity for revisions to avoid wasted costs [11]. In terms of competition, Pop Studio is surrounded by regional competitors in Surabaya:

e-ISSN : 2356-2579 | p-ISSN : 1412-2693, DOI : 10.62411/tc.v25i3.16234

1. Sultan 3D Print: Excels in a low-cost pricing strategy but does not provide technical design guidance [4].
2. Kilat 3D Print: Focuses on express production, but quality is often inconsistent and does not offer reverse engineering for functional parts.
3. Kreatif3d.id: Dominates the segment of toy collectors and aesthetic figurines, but neglects the precision needs of the mechanical engineering industry.

4.3. Preparation of the SWOT Analysis

The process of identifying internal and external environmental factors at Pop Studio was conducted by extracting all primary data obtained from in-depth interviews with management, direct observations at the Surabaya Industrial Training Center [3], and the tabulation of questionnaires distributed to 36 target market respondents. Through the processing of this descriptive qualitative data, the variables affecting the sustainability of Pop Studio's business were classified into the four main quadrants of the SWOT analysis [7], namely strengths and weaknesses as representations of the organization's internal conditions, and opportunities and threats as representations of the dynamics of the external industrial environment. This classification aims to objectively map the actual operational capacity of the Pop Studio startup amidst the intense competition in Surabaya's regional digital manufacturing services sector. The results of this identification serve as a crucial foundation for management to recognize the unique services that must be maintained and to mitigate operational risks that could hinder future business growth. Below is the complete tabulation of the SWOT factor identification matrix successfully formulated based on real-world field data and Pop Studio's evaluation workbook.

Table 1. SWOT Analysis Pop Studio

STRENGTHS 1. One-stop solution from design to finishing 2. No minimum order (supports customization and prototyping) 3. Specialization in jig and fixture design (niche market) 4. Reverse engineering for replacement parts 5. Support for non-technical users 6. Coloring studio and 3D printing courses	*WEAKNESSES* 1. The complexity of services increases the operational burden 2. Processing times are relatively longer 3. HR efficiency is not yet optimal 4. Reliance on individual skills 5. Differentiation is not yet strong & switching costs are low 6. HR resources are spread too thin, reducing the efficiency of the core business (production & primary services)
OPPORTUNITIES 1. Adoption of 3D printing: The trend toward custom and personalized products is on the rise 2. Demand for emotional products (merchandise, action figures) is increasing 3. The need for prototyping among SMES is growing 4. Design trends are changing rapidly 5. There are still few players in the jig and fixture market 6. Opening new revenue streams and increasing engagement through workshops and creative experiences	*THREATS* 1. Competitors are becoming more specialized and numerous 2. Low-cost competitors are quickly capturing the price-sensitive market 3. Raw material prices are unstable 4. Risk of imitation due to increasingly accessible technology 5. 3D printing technology continues to advance (leading to more competitors) 6. Demand for experiential services is unstable, posing a risk of failing to cover operating costs

Pop Studio has an internal structure characterized by several strategic strengths, with its integrated services (one-stop solution) from design to finishing serving as a key advantage in serving customers who lack technical expertise. Additionally, its policy of no minimum order requirements provides substantial support for the development of custom products and specialized prototyping for micro-entrepreneurs [4]. Specialization in jig and fixture design positions this entity in a commercial niche market that has not yet been seriously explored by local competitors. Reverse engineering capabilities for repairing replacement parts, along with proactive support for non-technical users, further underscore the high level of functional differentiation in its services [11]. Furthermore, the availability of interactive facilities such as a coloring studio and the hosting of 3D printing courses enriches the business portfolio with engaging educational elements. However, these strengths are accompanied by a series of

e-ISSN : 2356-2579 | p-ISSN : 1412-2693, DOI : 10.62411/tc.v25i3.16234

pressing internal weaknesses, such as the high complexity of services, which linearly increases the daily operational burden on the team. Relatively slower processing times and human resource (HR) performance efficiency that has not yet reached an optimal level also constitute structural weaknesses. The production process's reliance on a single individual's skills creates a potential bottleneck that could disrupt operational smoothness [5]. Additionally, the lack of widespread marketing of the differentiation image causes customer switching cost indicators to remain at a vulnerable level. The phenomenon of HR focus being split between primary manufacturing activities and the provision of art-painting experience services also impacts the efficiency of this startup's core business.

In the external analysis dimension, the dynamics of the additive manufacturing industry present a variety of highly strategic opportunities to be accelerated to expand market penetration. The adoption of 3D printing technology, coupled with the surge in demand for custom and personalized products, breathes new life into Pop Studio's relevance in the eyes of consumers [4]. Demand for micro-scale emotional products, such as merchandise and action figures, is also escalating in tandem with rapidly evolving design trends [9]. The growing need for prototyping services among local SMEs, coupled with a competitive void in the supply of jigs and fixtures, opens up a highly potential niche market for B2B business operations [3]. Furthermore, the opportunity to generate new revenue streams through educational workshops and creative experiences promises a profitable increase in engagement. Nevertheless, Pop Studio must remain vigilant against a series of external threats that continue to loom over its industry share growth. The emergence of increasingly segmented, numerous service providers who dare to offer cheap and fast solutions poses a significant risk of overtaking market share that is sensitive to service pricing [4]. Fluctuations in the prices of imported raw materials in the unstable free market constantly exert fluctuating pressure on the company's profit margin calculations. The risk of business model imitation is also becoming increasingly unavoidable as the public gains easier access to 3D printing technology on the market. This situation is exacerbated by the massive development of 3D printing technology, which attracts new players every year [9]. Additionally, fluctuations in consumer interest in offline experience services are considered quite risky because they can result in revenue failing to cover the operational costs that have been incurred

4.4. Formulating Business Strategies Using the TOWS Matrix

After all internal (strengths and weaknesses) and external (opportunities and threats) factors have been successfully identified and systematically mapped in the previous subsection, the next crucial step in strategic planning is to formulate alternative operational policies using the TOWS matrix (Threats, Opportunities, Weaknesses, Strengths). The TOWS matrix is a prescriptive tool that works by cross-matching internal and external variables to generate tactical formulations that are adaptive to the dynamics of the digital manufacturing industry. Through this approach, Pop Studio can develop four main strategic quadrants: the SO strategy (maximizing strengths to seize opportunities), the WO strategy (leveraging opportunities to minimize weaknesses), the ST strategy (using strengths to counter threats), and the WT strategy (minimizing weaknesses to avoid threats) [6]. This formulation is crucial to ensure that every expansion or efficiency decision made by management is grounded in a robust and measurable analysis of the business environment. This step also helps Pop Studio move beyond generic strategies toward differentiation tactics that offer unique competitive advantages. Table 2 presents a visualization of Pop Studio's TOWS confrontation matrix, ready for implementation

Table 2. TOWS Matrixs

e-ISSN : 2356-2579 | p-ISSN : 1412-2693, DOI : 10.62411/tc.v25i3.16234

Confrontation Matrix			***Opportunities*** 1. The trend toward customization and personalization is on the rise 2. Demand for emotional products is on the rise 3. The need for prototyping among SMEs is on the rise 4. Design trends are changing rapidly 5. The jig and fixture market has few players 6. Creative experience communities						***Threats*** 1. Numerous specific competitors 2. Low-cost and fast competitors 3. Unstable raw material prices 4. Risk of service imitation 5. Advancements in 3D printing technology 6. Fluctuating market demand					
			1	2	3	4	5	6	1	2	3	4	5	6
Strengths	1. One-stop solution 2. No minimum order 3. Specializing in jig and fixture design 4. Reverse engineering 5. Support for non-technical users 6. Coloring studio and 3D printing courses	1	x		x	x	x						x	
		2	x		x			x	x	x	x		x	
		3	x		x	x	x		x	x		x	x	
		4	x	x	x				x	x		x	x	
		5	x	x	x			x	x	x		x		
		6		x				x	x		x	x		x
Weaknesses	1. Complex operations 2. Outdated production processes 3. Human resource efficiency 4. Reliance on individuals 5. Lack of differentiation and low cash flow 6. Distractions affecting human resource focus	1					x						x	
		2					x	x					x	
		3											x	
		4				x		x					x	
		5	x	x	x	x								
		6												

The alternative strategic formulations derived from the TOWS matrix in Table 2 present a systematic tactical roadmap for Pop Studio to consolidate its competitive position in the regional market. The interplay between the factors of strengths, weaknesses, opportunities, and threats outlined above is analyzed in depth to determine the priorities for the startup's commercialization efforts. This cross-analysis of variables aims to translate descriptive qualitative findings from internal and external observations into a series of tactical actions that are adaptive to the dynamics of the digital manufacturing industry [6]. This strategic engineering process is divided into four main pillars: the offensive strategy pillar (SO), the improvement strategy pillar (WO), the reorganization strategy pillar (ST), and the defensive strategy pillar (WT). Through the decomposition of these pillars, startup management can navigate operational obstacles and narrow service gaps in a more measurable and practical manner

4.5. Extensive Discussion on Business Strategy Formulation

This extensive discussion on the formulation of Pop Studio's business strategy aims to provide an in-depth analysis of how the action plans formulated in the TOWS matrix can be implemented in the real-world context of the digital manufacturing industry in Surabaya. Through this discussion, each strategic alternative (SO, WO, ST, and WT) will be examined not only from the perspective of 3D printing technology functionality but also from the viewpoints of operations management, human resource efficiency, and the penetration of a creative marketing mix. This discussion is grounded in empirical field findings and consumer digital behavior data that represent real challenges within the business incubator ecosystem [3], [11]. By integrating strategic management theory and polymer materials engineering, Pop Studio is expected to create a measurable business development roadmap to build long-term competitive advantage. Therefore, the subsequent discussion will thoroughly examine four key areas of tactical policy to optimize the organization's full potential while eliminating internal vulnerabilities to external competitive threats.

e-ISSN : 2356-2579 | p-ISSN : 1412-2693, DOI : 10.62411/tc.v25i3.16234

Table 3. Business Development Strategies Based on the TOWS Matrix

***Strategy* SWOT**	
S-O ***Attack strategy***	PopStudio leverages its strengths to capitalize on market opportunities: 1. PopStudio offers a one-stop solution to address the growing demand for customization, personalization, and prototyping among SMES. The focus is on segments that require a comprehensive solution from concept to finished product rather than just printing services. (ref: S1 O1, O3, O4, O5) 2. Flexibility with no minimum order is used to reach the personal market, communities, and early-stage SMEs that require product trials or small-scale production before scaling up. This aligns with trends in emotional products and the custom market. (ref: S2 O1, O3) 3. Specialization in jigs & fixtures and reverse engineering is developed as a niche advantage to capture market opportunities with minimal competition, particularly for functional needs and small-scale industries. (ref: S3, S4 O3, O5) 4. Non-technical support is utilized to attract new users unfamiliar with 3D printing, thereby reducing market entry barriers. (ref: S5, O1, O3, O4) 5. Coloring studio services and courses are utilized as value-added offerings to capture trends in creative experiences and community engagement, rather than as the primary revenue stream. (ref: S6 O2, O6)
W-O ***Change Strategy***	PopStudio is capitalizing on opportunities to address internal weaknesses: 1. Service complexity is reduced by focusing on services most relevant to market trends—namely custom products and prototyping—thereby ensuring more controlled operations. (ref: W1, O5) 2. Production lead times are improved through process standardization to meet the growing demand from the custom market and SMEs, which typically require faster turnaround times. (ref: W2, O5, O6) 3. HR efficiency and individual dependency are reduced through task division and enhanced technical skills, enabling the capture of prototyping and industrial use opportunities. (ref: W4, O4, O6) 4. Differentiation is strengthened through clear positioning as a "custom & prototyping solution," rather than merely a general printing service, to prevent easy substitution. (ref: W5,O1, O2, O3, O4)
S-T ***Reorganize Strategy***	PopStudio leverages its strengths to mitigate the impact of threats: 1. Service complexity is reduced by focusing on services most relevant to market trends—namely custom products and prototyping—ensuring more controlled operations. (ref: W1 O5) 2. Production lead times are improved through process standardization to meet the growing demand from the custom market and SMEs, which typically require faster turnaround times. (ref: W2 O5, O6) 3. Labor efficiency is enhanced and reliance on individual expertise is reduced through task division and improved technical skills, enabling the company to capitalize on prototyping and industrial applications. (ref: W4 O4, O6) 4. Differentiation is strengthened through clear positioning as a "custom & prototyping solution," rather than merely a general printing service, to prevent easy substitution. (ref: W5 O1, O2, O3, O4)
W-T ***Defend Strategy***	PopStudio minimizes weaknesses to avoid threats: • Operational efficiency is improved through process simplification, the use of technology (AI, 3D scanning, and design tools), and workflow optimization to compete with low-cost, fast competitors. (ref: W1, W2, T5) • Reliance on individuals is reduced by enhancing team competencies, establishing clear division of labor, and strengthening value-based marketing focused on quality and functionality to avoid getting caught in a price war. (ref: W3, W4, T5)

The operational details outlined in Table 3 above confirm that Pop Studio has significant flexibility to adapt to current trends in the creative industry. The emphasis on integrated services (a one-stop solution) has proven to be a key factor in eliminating barriers for

e-ISSN : 2356-2579 | p-ISSN : 1412-2693, DOI : 10.62411/tc.v25i3.16234

general consumers, while also serving as a protective shield against competitors who rely on low prices. On the other hand, improvements in human resource efficiency and the standardization of production timelines are emphasized as absolute prerequisites to prevent the company from becoming paralyzed when facing a surge in orders. This harmonization of offensive and defensive strategies creates a startup business ecosystem that is not only focused on short-term profit but also on building long-term loyalty. A more extensive elaboration on the implications of each of these strategic pillars will be critically analyzed in the following subsections.

4.5.1. *Capitalizing on Market Opportunities Through the Integration of the Strength-Opportunity (SO) Offensive Strategy*

The SO (Strength-Opportunity) strategy is an offensive approach that aggressively leverages internal strengths to capture rapidly growing macro-market opportunities. Based on the confrontation matrix, the advantages of integrated services from design to finishing (one-stop solution) and flexibility without minimum order requirements have a strong correlation with the rising trend of personalized product customization and the prototyping needs of SMES [4]. This opens the door for Pop Studio to launch a 'design-print-finishing' service package designed to facilitate the needs of startup innovators in Surabaya. This proactive approach can directly lower market entry barriers for customers who are not yet familiar with additive printing technology [11]. Thus, Pop Studio can dominate the market segment requiring full support from the conceptual stage through to a market-ready physical product.

From a competitive advantage perspective, the inability of 73% of the target market to master 3D modeling software represents an absolute differentiation niche that must be exploited through this SO strategy. While the majority of regional competitors merely act as recipients of print-ready digital files [4], Pop Studio positions itself as a collaborative partner from the initial ideation stage [11]. This strategic partnership not only solves customers' technical problems but also builds a very strong emotional connection (brand attachment) that is difficult for competitors to replicate. Furthermore, development efforts are also focused on targeting a niche market involving the production of manufacturing aids (jigs & fixtures) and the replication of precision parts for medium-sized industrial players. Through this synergy, Pop Studio does not merely sell molten plastic commodities but rather offers engineering solutions that provide high economic value for enhancing customer business efficiency.

4.5.2 Operational Restructuring of Startups Through the Weakness-Opportunity (WO) Strategy

The WO (Weakness-Opportunity) strategy is designed as an internal stabilization measure that leverages external opportunities to eliminate operational weaknesses within the organization. Pop Studio's workflow reliance on a single designer's expertise and relatively long production times constitute critical weaknesses [5] that can be addressed by capitalizing on the rising trend of product customization [4]. The opportunity presented by the growing interest of SMEs in rapid prototyping should serve as the primary driver for management to improve the efficiency of the startup's production line [3]. Through this adaptation strategy, the team can design a more structured workflow to accelerate daily production processes without compromising print quality. By capitalizing on high market demand, Pop Studio can invest a portion of its revenue to strengthen the team's capacity, making it more resilient.

This operational improvement is implemented through the development of a Standard Operating Procedure (SOP) for design work that limits the maximum number of revisions to two per order contract [11]. This strict limitation is crucial to prevent wasted designer hours and to shorten the lead time—a common customer complaint. Additionally, Pop Studio needs to build a database of print-ready parametric design templates for popular souvenir and hobby merchandise categories in the market [9]. The availability of this digital library will significantly reduce pre-production lead times, as operators will no longer need to redraw models from scratch. Through a combination of streamlined SOPs and the use of a template database,

e-ISSN : 2356-2579 | p-ISSN : 1412-2693, DOI : 10.62411/tc.v25i3.16234

operational complexity can be drastically reduced, thereby consistently improving daily production capacity efficiency.

4.5.3. Technical Defense Engineering Through the Strength-Threat (ST) Protection Strategy

The ST (Strength-Threat) strategy calls for tactical reorganization that leverages the organization's internal strengths to minimize exposure to threats from a volatile external environment. Threats in the form of similar competitors specializing in ultra-fast delivery times and extreme price wars require Pop Studio to avoid competing in the commodity segment [4]. Pop Studio must deploy its strengths in reverse engineering and precision mechanical design specialization to avoid direct competition with low-cost players. Reliability in technical support and guarantees of dimensional precision serve as protective instruments that distinguish the startup from amateur home-based players [11]. By building this fortress of technical competence, Pop Studio can create a positioning advantage that is safe from the threat of business model cloning.

The implementation of this protection strategy is realized through a value-based positioning marketing campaign that educates consumers that the price offered is compensation for the guarantee of precision and functional reliability. Material education is a key factor: Pop Studio allocates specialized Polylactic Acid (PLA) for hobbyists' visual needs, while Polyethylene Terephthalate Glycol (PETG) is allocated for large-scale B2B industrial parts projects requiring extreme mechanical durability. PETG's superior properties in impact resistance, tensile strength, and high-temperature resistance make it a high-value solution for factory mechanical components in Surabaya. Through this hybrid material blend, Pop Studio can convincingly demonstrate to customers that they are investing in reliable engineering solutions, not merely purchasing generic 3D-printed plastic [10].

4.5.4. Strengthening Business Sustainability Through the Weakness-Threat (WT) Defensive Strategy

The WT (Weakness-Threat) strategy is an essential defensive maneuver aimed at minimizing an organization's internal weaknesses while avoiding damaging external threats. Reliance on a single designer's expertise is highly risky when faced with the pressure of urgent delivery demands from price-sensitive markets [4], [5]. If a key staff member faces issues, Pop Studio's production workflow would suffer a complete shutdown, potentially damaging the startup's reputation in the eyes of customers. Therefore, this defensive strategy prioritizes internal restructuring and the minimization of operational failure risks to ensure business continuity. By designing an autonomous work system, Pop Studio can reduce organizational vulnerability to the turbulence of regional market competition.

Concrete defensive measures are implemented through a daily cross-training program that equips 3D printer operators with the basic skills to operate slicing software and perform simple CAD file geometry corrections [5]. This decentralization of expertise ensures that the production line remains operational even if the lead designer is unable to be present at the studio. Additionally, to protect profit margins from the threat of instability in the prices of imported polymer raw materials, Pop Studio must implement an automatic pricing model based on the weight of the printed material [12]. This weight-based pricing system has proven to be more stable in securing operational cash flow compared to a pricing model based purely on printing duration. Through the integration of cross-training for staff and material pricing efficiency, Pop Studio can reduce production inefficiencies while safeguarding the startup's financial sustainability from the risk of operational cost losses.

5. CONCLUSION

The evolution of the digital manufacturing ecosystem is driving 3D printing service providers to shift from the role of mere machine operators to that of architects of fully integrated

e-ISSN : 2356-2579 | p-ISSN : 1412-2693, DOI : 10.62411/tc.v25i3.16234

product solutions [4]. A strategic analysis of the Pop Studio startup demonstrates that the problem statement regarding consumers' inability to design in 3D (experienced by 73% of the target market) was precisely addressed through the formulation of an end-to-end value proposition (one-stop solution) [11]. Mapping internal and external conditions through a SWOT analysis framework reveals that Pop Studio possesses a strong competitive advantage in consulting and reverse engineering services, although it still needs to address operational weaknesses such as slow lead times and vulnerabilities stemming from reliance on a single expert designer [5], [7]. The integration of these internal strengths is highly relevant to the surge in product customization trends and the need for rapid prototyping among creative SMEs in the Greater Surabaya area, thereby validating the organization's position to expand amidst the threat of price-cutting competitors [3], [4].

To ensure targeted growth, the TOWS matrix analysis yields a set of strategic recommendations that Pop Studio must implement immediately [6]. The most critical strategy for management is to pursue aggressive penetration (SO Strategy) into the B2B sector by offering manufacturing tooling services (Jigs & Fixtures) leveraging the superior mechanical properties of PETG material [10]. Additionally, the company must expand its B2C business model by commercializing 3D coloring booths (creative experience) to build emotional bonds and customer loyalty. To support this expansion without compromising service quality, Pop Studio is recommended to implement improvement strategies (WO and WT Strategies) through the adoption of standardized operating procedures (SOPs), limiting CAD revision iterations within a single order contract, and distributing slicer operational expertise to all staff to eliminate daily production bottlenecks [5], [11].

From both theoretical and managerial perspectives, this study confirms that service differentiation based on the quality of client support is far more effective than competing purely on low prices in the Industry 4.0 sector [4]. For the Surabaya Industrial Training Center Business Incubator, it is hoped that these findings can serve as a foundation for facilitating an industry-standard CAD designer competency certification program for its incubated tenants [3], as well as for fostering strategic partnerships with local manufacturing associations. For future research, it is highly recommended to examine the financial viability (Net Present Value and Payback Period) related to investments in industrial-scale 3D printing machines [4], as well as to empirically test the effectiveness of reducing material waste costs following the implementation of automated production scheduling [12].

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e-ISSN : 2356-2579 | p-ISSN : 1412-2693, DOI : 10.62411/tc.v25i3.16234