Available online at: http://e-jurnal.lppmunsera.org/index.php/JSMI

Jurnal Sistem dan Manajemen Industri
(Journal System and Management of Industries)

ISSN (Print) 2580-2887 ISSN (Online) 2580-2895

Innovative canting: A triz approach to improve traditional batik production process in small and medium enterprise

Taufiq Immawan[1*], Fauzan Mahardika Pratama[1], Muhammad Iqbal Rofif[2], Farid Agung Waskita[2], Meilinda Fitriani Nur Maghfiroh[1,3]

[1]Department of Industrial Engineering, Universitas Islam Indonesia, Jalan Kaliurang KM 14.5, Yogyakarta 55584, Indonesia
[2]Master Program in Industrial Engineering, Universitas Islam Indonesia, Jalan Kaliurang KM 14.5, Yogyakarta 55584, Indonesia
[3]Faculty of Transport and Logistics, Muscat University, HCV5+PP3, Al Ghubrah St, Muscat, Oman

ARTICLE INFORMATION

Article history:

Received: February 12, 2025
Revised: April 18, 2025
Accepted: June 13, 2025

Keywords:

Batik
Triz
Function analysis
Product design and development

*Corresponding Author

Taufiq Immawan
E-mail: taufiq.immawan@uii.ac.id

ABSTRACT

This research aims to improve the efficiency of the canting tool used in the Batik-making process in Giriloyo Village. One of the main issues identified is the suboptimal size of the canting spout, which causes wax blockages due to dirt particles. This study employs TRIZ tools, including Function Analysis, to identify problems, develop innovative solutions to the issues, and develop solutions that address contradictions in the canting system. The analysis results indicate that several inventive principles, such as Merging, Beforehand Cushioning, Segmentation, and Feedback, can enhance the canting tool's performance. Proposed solutions include adding a heater, filter, flow regulator, and interchangeable canting spouts to meet different needs. These solutions can accelerate the Batik-making process, reduce production costs, and enhance market competitiveness. However, further verification is required to validate the proposed design's superiority over traditional canting tools. This research opens opportunities for further development in Batik tool innovations to enhance the sustainability of the Batik creative industry in Indonesia.

1. INTRODUCTION

Innovation and creativity have become broadly used terms in many national development strategies. The Creative Economy concept has been derived from innovation and creativity in Creative Industries [1]. Various economic experts often express the creative industry as the fourth-wave industry after agriculture, industry, and information technology [2]. Within this classification, Batik can be under art, crafts, or fashion subsectors. The development of the Batik craft industry in Indonesia faces various challenges that need to be addressed to promote further growth.

The Indonesian Batik industry is a sector with many SMEs. However, Batik SMEs are hardly known for their ecologically sustainable behavior [3]. Before the monetary crisis in 1997, Batik SMEs experienced rapid growth. The Indonesian Batik industry has significantly developed, especially in the 1980s when Batik was adopted as formal wear for state and formal events [4]. This period marked the rise of Batik's status both nationally and internationally. The Batik industry is spread across various regions in Java, each developing a distinctive style, such as Pekalongan, Surakarta, Yogyakarta, Lasem, Cirebon, and Sragen, with unique motifs that reflect local identity. Batik production techniques are categorized into three main types: hand-drawn Batik (using canting), stamped Batik (using copper stamps), and printed Batik [5]. The evolution of the Batik industry in Indonesia is closely related to its long history, reflecting a blend of industrial processes and traditional crafts.

In addition, UNESCO has recognized Batik as an Intangible Cultural Heritage of Humanity, further strengthening its position in Indonesian and world culture. From an industrial perspective, the growth of Batik is closely linked to the national textile industry, which currently faces stiff competition, especially from China [6]. Indonesian textile products face intense competition in the domestic market due to the lower prices of textiles imported from China [7]. This price disparity has made locally produced textiles less attractive to consumers, placing the Indonesian textile industry in a precarious position and threatening its long-term sustainability. The challenges have been further exacerbated by economic globalization, which has compelled Indonesia to eliminate both tariff and non-tariff trade barriers, including those on textile imports [8]. As a result, various sectors within the textile industry, including fabric production and garment manufacturing, are experiencing significant pressure to remain competitive.

Despite these challenges, Indonesian Batik maintains its status as a unique artisanal craft that heavily relies on the creativity of its artisans in designing, innovating with different fabric types, and marketing their products in a specialized manner [9]. As a handmade craft, the quality of Batik plays a crucial role in determining its value, while its market segmentation also influences its pricing strategy. However, there remains a lack of awareness among many Batik artisans regarding the importance of continuous innovation [10]. Many artisans still perceive Batik making as a traditional, inherited occupation rather than an evolving creative industry. Consequently, they tend to focus on reproducing established motifs rather than exploring new, contemporary designs that could enhance the competitiveness of Indonesian Batik in both domestic and international markets [11].

As a type of clothing, Batik is closely related to fashion development, which is part of the creative industry. The Batik industry is vital to Indonesia's economy, particularly in rural areas, where it provides employment opportunities and supports local artisans [12]. The industry is classified under the creative economy sector, which is important for Indonesian economic development [13].

Yogyakarta Special Region is known as one of the centers of Batik in Indonesia. The Batik creative industry in this region has great growth potential, especially as a craft subsector. Crafts, as part of the creative industry, not only meet the practical needs of artisans but also contribute to the preservation of Batik art by making the craft more accessible to a broader audience, including children with special needs [14]. This research focuses on the role of hand-drawn Batik artisan groups in Giriloyo as cultural preservers and contributors to local economic resilience. This study aims to support innovation that sustains the Batik industry's cultural and economic vitality by addressing challenges in the production process, such as inefficiencies in the canting tool.

Batik-making activities are a preserved cultural heritage and a source of livelihood for the local community. Activities such as Batik production, product galleries and exhibitions, Batik courses for tourists, and restaurants offering local food and beverages have turned this village into a sustainable creative economy center. This village plays a crucial role in preserving the art of Batik, although there are challenges in the production process. The traditional Batik tool, or canting, still has significant limitations, slowing the motif Batik-making process. It takes 3 to 6 months to complete a single piece of Batik fabric, leading to high product prices and difficulty in selling it in the market.

The canting is the primary tool in the traditional Batik-making process, and it is used to apply hot wax to fabric. While it is a cultural icon of Indonesia, the canting has several drawbacks that hinder the development of the Batik industry. Using a traditional canting is labor-intensive and requires high skill and artistry. Artisans must maintain a steady hand to ensure that the wax is applied accurately, which can be physically demanding and lead to musculoskeletal issues over time [15]. Moreover, the manual process using traditional canting is time-consuming, making it less efficient for large-scale production [16].

Innovations, such as the development of electric canting, have been attempted to improve efficiency and productivity. However, early prototypes of electric canting still have limitations, including less ergonomic designs and suboptimal material durability [17]. On the other hand, alternatives like canting stamps made from recycled paper offer a more economical solution but lack sufficient durability for long-term use. Additionally, access to production tools like canting, especially in remote areas, remains a challenge. Many micro-scale Batik artisans struggle to obtain equipment that meets their needs [18]. This highlights that while canting is an integral part of cultural heritage, further technological development and better tool distribution are needed to support the sustainability of Indonesia's Batik industry.

This research aims to improve the efficiency of the canting tool in Batik production by utilizing two innovative analysis methods: Function Analysis and TRIZ (Theory of Inventive Problem Solving). The primary goal of this research is to identify the current problems with the canting tool through Function Analysis, which allows for mapping its functions and uncovering design deficiencies. The TRIZ method will provide innovative solutions by resolving contradictions and improving one aspect of the problem

http://dx.doi.org/10.30656/jsmi.v9i1.10250

without worsening other functions, based on the 40 inventive principles that have proven effective in solving similar issues [19]. By applying TRIZ principles, a new canting design is expected to be developed that is more efficient and better suited to the needs of Batik production. This research is anticipated to overcome the challenges in the Batik production process, accelerate production time, and reduce costs, thereby enhancing the competitiveness and sustainability of the Batik industry in Indonesia.

The main contributions of this research are described as follows:

1) This research develops an innovative approach to improving the canting tool used in Batik production. The study's use of TRIZ tools, including Function Analysis, provides a systematic framework for identifying design deficiencies and enhancing the tool's efficiency.
2) It investigates specific inventive principles, including Merging, Beforehand Cushioning, Segmentation, and Feedback, which are applied to address technical contradictions in the canting tool, such as wax flow control and dirt prevention, without compromising other functionalities.
3) This study contributes to optimizing the Batik-making process by proposing modifications like adding a heater, incorporating a filter, adjusting the flow regulator, and introducing interchangeable canting spouts. These improvements aim to reduce production time, lower costs, and increase the competitiveness of Batik products in the market.
4) As a practical guide, this research offers insights for artisans and producers in the Batik industry to enhance tool functionality and operational efficiency, supporting the long-term sustainability of Indonesia's Batik creative industry.

2. RELATED WORK

TRIZ is an acronym for the Russian term Teoriya Resheniya Izobretatelskikh Zadatch, translated as "Theory of Inventive Problem Solving." Russian scientist Genrich S. Altshuller developed this method in 1946 [20]. The TRIZ philosophy has evolved from its original four pillars (ideality, resources, functionality, and contradictions), with the addition of a fifth pillar (space/time/interface), into seven updated pillars, including system transfer and system transition [21]. TRIZ is a problem-solving methodology based on logic and data rather than intuition, designed to accelerate the creative problem-solving process. It can be applied to various types of problems, both technical and non-technical [20].

By utilizing the appropriate tools, various TRIZ solution principles can be generated and then translated into specific solutions that address real-world problems, which can subsequently be developed into technical innovations. Due to its effectiveness and broad applicability, TRIZ has been widely adopted by academics and industry professionals for several decades [19], [20], [22], [23]. It has been applied not only in traditional engineering fields but also in business and management [24], services [25], [26], [27], green supply chain and sustainable innovation [28], [29], [30], [31], as well as in maintenance [32], [33], [34].

To clarify the distinction between existing

Table 1. Literature review and research

Aspect	Literature review	Research conducted
Definition	Focused on mechanical improvements (e.g., spout taper in US2567960A), ergonomic handles (IDP000036576), or electric prototypes.	Applies TRIZ methodology to resolve technical contradictions in canting design, integrating Function Analysis and inventive principles.
Objective	Optimize single parameters (e.g., clogging reduction, ergonomics) without systematic trade-off analysis.	Optimize single parameters (e.g., clogging reduction, ergonomics) without systematic trade-off analysis. Identify and resolve contradictions (e.g., precision vs. reliability) using TRIZ tools to enhance overall canting performance.
Data source	Patents (US2567960A), prototypes, and artisan feedback.	Direct observation of canting use in Giriloyo Village, interviews with artisans, and functional testing of prototypes.
Method	Empirical trials, mechanical redesigns, or material substitutions (e.g., recycled paper canting stamps.	Function Analysis to map canting subsystems, Contradiction Matrix (Parameters #27–28), and inventive principles (Merging, Feedback).
Results	Incremental improvements (e.g., 20% faster wax flow in electric canting.	Development of a more efficient canting design with features such as heaters, filters, flow regulators, and replaceable spouts.
Contribution	Provide a theoretical basis and justification for the research conducted.	Providing real solutions that can increase the efficiency of Batik production in Giriloyo.

Table 2. Previous research

Author	Year	Method	Business and management	Sustainable	Service	Product development
Chou [21]	2021	Triz				✓
Aguilar-Lasserre *et al*. [23]	2020	Triz		✓		✓
Ekmekci and Koksal [19]	2015	Triz				✓
Delgado-Maciel *et al*. [24]	2020	Triz	✓			
Souchkov [25]	2019	Triz	✓		✓	
Kose and Guner [28]	2020	Triz			✓	
Shie *et al*. [27]	2022	Triz			✓	
This Research		Triz	✓	✓	✓	✓

theoretical knowledge and the contributions of this study, Table 1 presents a comparative summary of the literature review and the research conducted to clarify the distinction between existing theoretical knowledge and this study's contributions. It highlights key differences in purpose, methodology, data sources, and outcomes. This comparison emphasizes how the current research builds upon existing knowledge by providing practical innovations tailored to solve real-world problems in the traditional Batik-making process.

Table 2 provides a comparative overview of previous research that applied the TRIZ methodology across various fields, including business and management, sustainability, service innovation, and product development. It illustrates how TRIZ has been widely adopted in different domains but rarely applied within traditional craft industries such as Batik. The table highlights that many studies have focused on single or dual aspects, such as product development or sustainability. This research stands out by addressing all four aspects simultaneously. By applying TRIZ not only for technical improvement but also to support sustainable practices, enhance service quality, and strengthen business competitiveness, this study offers a more holistic contribution to the creative industry, particularly in Batik production.

3. RESEARCH METHODS

TRIZ leverages available resources to improve system functionality and ideality. It requires converting between the factual and TRIZ domains, suggesting five steps for solving problems and converting solutions into specific outcomes. To generate generic solutions, designers or engineers must classify the TRIZ problem and select the appropriate tools to solve it. Each problem classification is associated with several knowledge-based tools, such as the 39 engineering parameters and contradiction matrix, along with the 40 inventive principles for resolving technical contradictions.

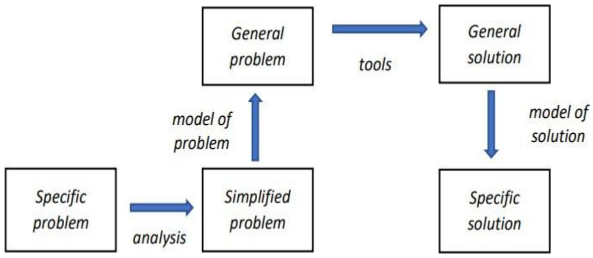

Fig. 1. Triz problem-solving flow

TRIZ minimizes time wasted in solving contradictory problems by applying various proven solution strategies. The method involves transforming specific problems into abstract ones, solving them at the abstract level, and translating the solutions into concrete forms. The TRIZ problem-solving process consists of five stages (Fig. 1).

3.1. Specific problem

The primary focus is to identify and define the problem in detail. A specific problem is an issue that arises within a particular context and is examined in depth based on its unique circumstances. This step involves gathering all relevant information about the problem, including background, conditions, and influencing variables. These steps aim to gain a deep understanding of the problem at hand so that the solution developed is completely aligned with the needs and no crucial aspects are overlooked [35].

The functional analysis method is designed to understand and resolve problems by analyzing the functions of a system or product. This process begins by identifying the central system and breaking it into individual components, each playing a specific role within the overall system [36]. Once the components are identified, the next step is to group them into a supersystem, a collection of components working together to perform a particular function. Our framework adapts TRIZ methodology to traditional craft tools through five stages.

 http://dx.doi.org/10.30656/jsmi.v9i1.10250

At this step, the target for each component and supersystem is established, which includes functional objectives such as efficiency, precision, or performance that must be achieved. The analysis is then conducted to understand how the components and surrounding systems interact in achieving the defined objectives (Fig. 2). This process helps identify potential issues such as inefficient wax flow, thermal imbalances, or component misalignment within the canting system, leading to problems like wax clogging, inconsistent application, and user discomfort during the Batik-making process [36].

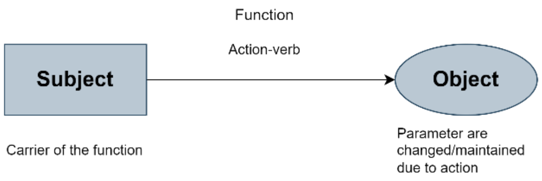

Fig. 2. Function analysis

3.2. Simplified problem

In the simplified problem stage of the TRIZ method, the previously identified problems are simplified using the Engineering Contradiction model [37]. This step seeks to identify and understand technical or functional contradictions within the system. These contradictions arise when two system parameters conflict, where improving one parameter reduces the performance of another [38].

The problem is simplified by focusing on the core contradiction, reducing its complexity. The engineering contradiction model breaks down the problem into a more structured form, with the involved parameters identified and deeply analyzed. Clearly defining these contradictions allows for developing focused and innovative solutions, utilizing TRIZ principles to resolve the problem without compromising other aspects of the system [36].

An engineering contradiction in TRIZ theory occurs when efforts to improve one aspect of a system inadvertently worsen another element. TRIZ uses IF, THEN, and BUT statements to describe scenarios where attempts to enhance one parameter negatively affect another [39]. The structure of engineering contradictions includes:

1. IF: Indicates the action or condition intended for improvement (improving parameter), typically representing the desired change to enhance performance, efficiency, or a specific system function.
2. THEN: Represents the positive outcome expected from the desired change, i.e., the intended result of improving the parameter mentioned in the IF clause.
3. BUT: Describes the adverse effect of the improvement (worsening parameter), usually impacting another parameter, thus creating the contradiction.

3.3. General problem

In the general problem stage, the simplified problem is further abstracted after contradiction analysis [36]. The first step is identifying the parameter targeted for improvement (improving parameter) and the parameter likely to deteriorate (worsening parameter). This contradiction arises because enhancing one parameter (e.g., measurement accuracy by reducing spout size) often negatively impacts another (e.g., reliability due to clogging) [39].

The 39 TRIZ parameters model aids in matching and analyzing how changes to one parameter affect others. By generalizing the problem into a more abstract form, foundational principles applicable to various similar situations can be identified, thus facilitating the development of more effective innovative solutions. This stage allows for framing the problem in a universal context and formulating optimal solutions to address technical contradictions efficiently.

3.4. General solution

The general solution step focuses on utilizing inventive principles derived from analyzing technical contradictions [36]. This process begins by leveraging the TRIZ contradiction matrix to identify relevant inventive principles based on the determined parameters, the improving parameter, and the worsening parameter from the 39 TRIZ Parameters [40].

TRIZ contradiction matrix shows this matrix, which provides a list of inventive principles that can be applied to address the conflict between these two parameters. Each parameter combination within the matrix indicates several applicable inventive tenets, such as segmentation, merging, or adding new elements. The discovered inventive principles are then tailored to the problem's specific context, ensuring that the developed solutions are general and pertinent to the situation at hand. TRIZ 40 Inventive Principles illustrates how creative solutions derived from TRIZ inventive principles facilitate the development of more innovative approaches to resolve technical contradictions without compromising overall system performance [41].

3.5. Specific solution

In the specific solution phase, the ideas generated from the inventive principles in the previous stage are developed into concrete and specific solutions. The inventive principles selected through the TRIZ contradiction matrix are translated into practical ideas that can be directly applied to the encountered problems [36].

This process involves adapting these principles to align with the context of the system or product being analyzed. Each generated idea undergoes thorough evaluation to ensure its effectiveness in resolving the technical contradictions without creating new issues. Once specific ideas are validated, the next step is to implement them in a tangible form, whether through design modifications, process changes, or other technical developments. This phase ensures that the solutions developed effectively address the initially identified problems while providing significant performance improvements.

4. RESULTS AND DISCUSSION

4.1. A systematic framework for canting tool innovation

Our framework adapts TRIZ methodology to traditional craft tools through four stages:

1. Problem mapping
   Function analysis to decompose canting sub-systems (spout, wax reservoir, handle) and interactions (e.g., wax flow, heat transfer).
2. Contradiction identification
   Pairing improving/worsening parameters using artisan input and observational data.
3. Principle selection
   TRIZ contradiction matrix inventive principles (merging, segmentation).
4. Solution validation
   Prototype testing with Batik artisans in Giriloyo Village.

This framework bridges TRIZ technical problem-solving with cultural craft preservation.

4.2. Problem statement

The Batik Village of Giriloyo faces several significant issues related to the traditional Batik production process. One major problem in the traditional Batik-making process is the limitation of the canting tool, particularly its ergonomics, functionality, and flow efficiency. The main challenge lies in the design of the canting's nozzle, the narrow spout that channels hot wax onto the fabric. Many artisans face difficulties due to the suboptimal nozzle dimensions. Specifically, a smaller nozzle is needed for detailed work, but this reduced size tends to be prone to clogging, while a larger nozzle improves flow but sacrifices precision. This trade-off between precision and reliability leads to slow wax flow and makes it difficult to create intricate patterns. Additionally, dirt or residue in the wax often clogs the nozzle (Fig. 3), disrupting the wax application and significantly delaying the overall production process. As a result, completing a single Batik fabric can take 3 to 6 months, making the production process highly inefficient.

This issue also results in high production costs, ultimately affecting the selling price of Batik. The high prices of Batik from Giriloyo become unaffordable for most consumers, leading to difficulties in sales and hindering the growth of the creative economy in the village. Therefore, effective solutions are necessary to address the issues with the canting to make the Batik production process more efficient and productive, allowing Batik to be sold at more accessible prices without compromising quality.

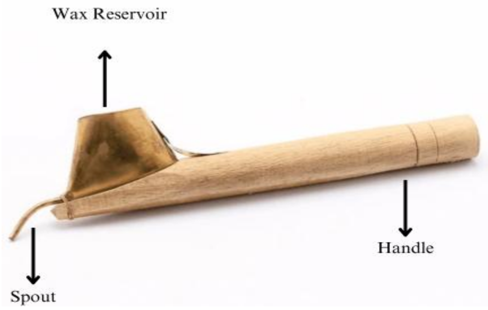

Fig. 3 Traditional canting design

.

The observed problems in the traditional canting tool include slow wax flow, difficulty creating delicate and detailed patterns, and frequent blockages due to dirt or impurities. These issues negatively impact the quality and efficiency of the Batik production process. While one initial hypothesis suggests that the nozzle size may contribute to these problems, other possible factors, such as the artisan's canting handling skills, temperature stability, and the physical properties of the wax, must also be considered.

To verify whether the nozzle size plays a key role in this issue, a functional analysis was conducted, examining the interaction of each component within the canting system. The analysis revealed that a smaller nozzle could theoretically improve the accuracy of wax application, but it also increases the risk of clogging, particularly when contaminants are present. Therefore, instead of immediately proposing a smaller nozzle as the solution, the study identifies an engineering contradiction: improving precision (e.g., through a smaller nozzle) potentially reduces reliability (e.g., due to higher clogging risk). This contradiction forms the basis for further exploration using TRIZ to find balanced, principle-based solutions without prematurely fixating on a single design modification. At this point, the problem presents a contradictory technical challenge. Modifying the canting's nozzle size is expected to improve the quality of the Batik and expedite the production process; however, it may worsen the system's ability to prevent dirt accumulation. In TRIZ analysis, such situations occur every day, where improving one aspect leads to another decline.

4.3. Function analysis tools

The following are the components of the canting system: components (box): hand, handle, spout, wax reservoir subsystem components (hexagonal): air, fabric holder target (circle): wax liquid: the wax liquid is the primary target here, as various components and

http://dx.doi.org/10.30656/jsmi.v9i1.10250

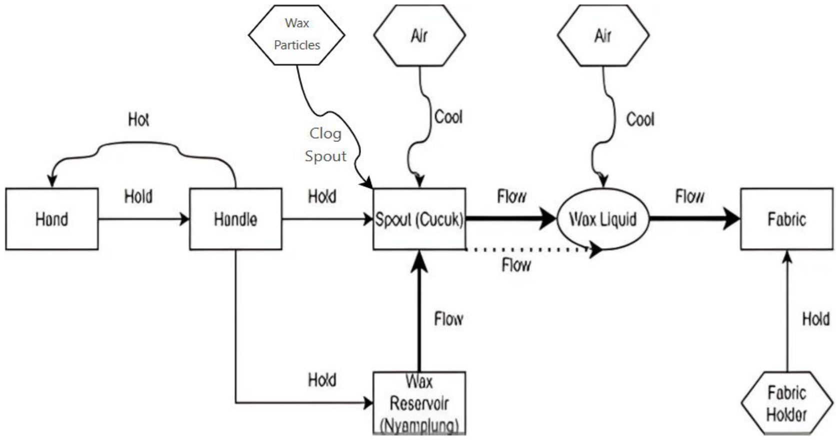

Fig. 4. Function analysis tools

Fig. 4 presents an analysis diagram illustrating the interactions between components:

1. Hand hold handle (normal): The hand typically holds the handle without problems or imbalances. However, transferring it from the handle to the hand is harmful, as it can cause burns.
2. Handle hold spout (normal): The handle holds the spout normally without issues.
3. Air cool spout (harmful): Cold air cools the spout, resulting in harmful interaction that can cause the wax inside the spout to solidify, hindering the Batik process.
4. Spout flow wax liquid (excessive): The flow from the spout to the wax liquid is excessive, potentially causing uncontrolled wax flow.
5. Spout flow wax liquid (insufficient): When the wax inside the spout solidifies due to cold air, it can obstruct the flow of the liquid.
6. Handle hot to hand (harmful): Heat transferred from the handle to the hand is harmful, as it can cause burns.
7. Air cooling wax liquid (harmful): Cold air cools the wax liquid, causing a harmful interaction that causes the wax to solidify before reaching the fabric.
8. Wax liquid flow fabric (excessive): The wax liquid flows to the fabric excessively. This occurs when the wax is too hot and lacks a cover, leading to spillage before touching the fabric.
9. Fabric holder hold fabric (normal): The fabric is usually held by the fabric holder, facilitating standard positioning.
10. Handle hold wax reservoir (normal): The handle holds the wax reservoir normally with no issues.
11. Wax reservoir flow spout (excessive): When the wax reservoir is too hot, wax flows excessively from the reservoir to the spout, overflowing wax liquid into the spout.

The functional model accounts for all relevant subsystems, including wax particles/dirt, which interact harmfully with the spout. It ensures a comprehensive analysis of factors affecting clogging.

4.4. Simplified problem

IF we reduce the size of the "Cucuk Canting," THEN this will improve accuracy when drawing patterns, as a smaller spout allows for finer, more detailed lines, especially in complex and high-precision designs.

By reducing the size of the spout, wax can be applied more precisely to the fabric, resulting in sharper and more accurate patterns. BUT, dirt from the wax can more easily clog the spout. The wax used in the Batik process often contains small particles or dirt (e.g., un-melted wax residues or environmental contaminants) that enter the spout (Fig. 4). These particles contribute to clogging, necessitating design solutions like filters or heated spouts to mitigate their impact.

When the size of the spout is reduced, the flow of wax becomes more sensitive to these contaminants, leading to clogs that impede the flow of wax. This reduces process efficiency and can disrupt the pattern-making process. Thus, while accuracy increases, the clogging issue becomes a primary challenge that must be addressed to reduce the spout size.

4.5. General problem

In the simplified problem stage, we have identified the engineering contradiction in the canting system, where reducing spout size can enhance pattern-drawing accuracy but causes the problem of wax clogging due to dirt. From this analysis, we can simplify the problem into a General Problem using TRIZ parameters.

a. Improving parameter: Parameter 28: Measurement accuracy, since reducing the spout size allows for more precise and detailed pattern drawing. However, this introduces a clogging issue.
b. Worsening parameter: Parameter 27: Reliability. The system's reliability decreases because a smaller spout becomes more susceptible to clogging,

disrupting wax flow and hindering the Batik-making process.

The solutions for dirt (filter) and cooling (heater) were evaluated together because they address interdependent failure modes in the canting system. Field tests showed that solving one issue without the other led to suboptimal performance (e.g., filters clogged faster without temperature control).

4.6. General solution

In the canting system, where there is a contradiction between the improving parameter (28: measurement accuracy) and the worsening parameter (27: reliability), the next step is to seek solutions from the TRIZ contradiction matrix. Based on this matrix, the relevant inventive principles to address this contradiction are:

1. Principle 5: Merging
   This principle encourages combining similar or complementary objects or functions to enhance the effectiveness and reliability of the system.
2. Principle 11: Beforehand cushioning
   This principle suggests preparing preventive measures before problems arise.
3. Principle 1: Segmentation
   This principle proposes dividing an object or system into smaller or modular parts to improve flexibility and efficiency.
4. Principle 23: Feedback
   This principle focuses on using feedback to monitor and control the process.

4.7. Specific solution

Based on the TRIZ principles identified to address the engineering contradiction in the canting system—namely, Principle 5: Merging, Principle 11: Beforehand Cushioning, Principle 1: Segmentation, and Principle 23: Feedback—each principle offers innovative solutions to tackle the issue of wax blockage while enhancing the accuracy of pattern drawing with a smaller spout.

1. Principle 5: Merging
   Fig. 5 Adding a Heater Merging involves combining separate elements into a unified system. In this case, integrating a heater into the canting tool, either within the nyamplung (wax reservoir) or the cucuk (spout), ensures that the wax remains at the optimal temperature throughout the process. This prevents the wax from solidifying prematurely, reducing the likelihood of clogs and ensuring a smooth, consistent wax flow. This directly enhances the tool's reliability and improves the accuracy of wax application on the fabric.
2. Principle 11: Beforehand cushioning
   Before-hand cushioning focuses on preventing potential issues before they happen. It incorporates a filter inside the nyamplung to remove impurities (Fig. 6) and a flow controller to adjust the size of the cucuk opening, prevent blockages, and ensure better control over wax flow (Fig. 7). This setup keeps the wax flowing smoothly and allows the user to fine-tune the precision of the application, improving both the accuracy of the design and the overall ease of use of the tool.

Fig. 5. Adding a heater

Fig. 6. Canting filter

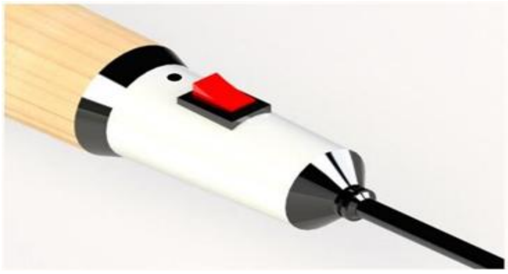

Fig. 7. Flow controller

3. Principle 1: Segmentation
   Segmentation involves breaking a component into modular, interchangeable parts. By making the cucuk (spout) replaceable with different-sized nozzles, the canting tool becomes adaptable to different levels of detail in the Batik design. Fig. 8 Spout that can be changed according to size. Larger spouts can be used for broad strokes, while smaller ones allow for more intricate details. This increases the adaptability of the tool, enhancing accuracy for various design needs while maintaining ease of use.
4. Principle 23: Feedback
   Feedback principle (Principle #23) This principle can be implemented by adding indicator lights that provide visual information regarding the status of the heating element.

http://dx.doi.org/10.30656/jsmi.v9i1.10250

The light will illuminate red when the heater is active. Fig. 9 Indicator light turns red when the heater is on and turns off when the heater is not in operation. Fig. 10 Indicator light turns black when the heater is on. This allows users to easily determine whether the heater is functioning properly, enhancing usability and reducing the risk of overheating or inadequate heating.

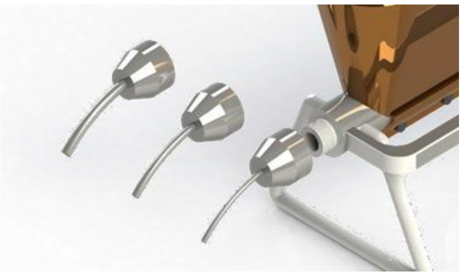

Fig. 8. Spout that can be changed according to size

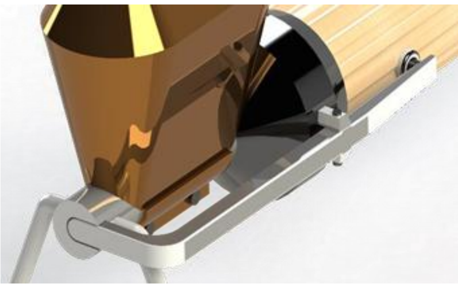

Fig. 9. Indicator light turns red when the heater is on

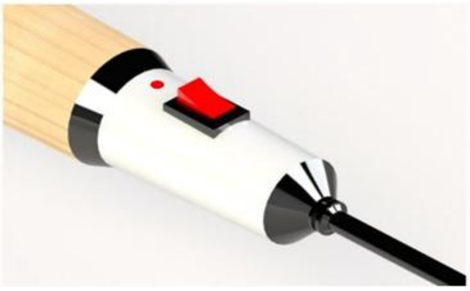

Fig. 10. Indicator light turns black when the heater is on

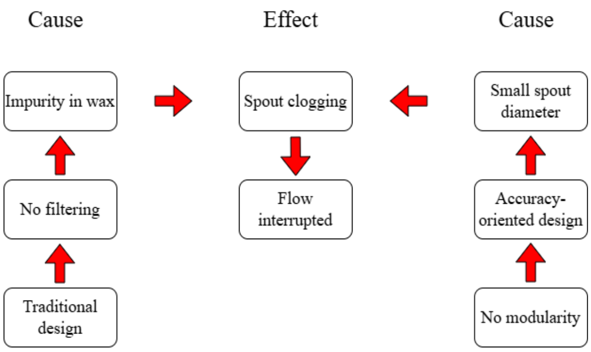

Fig. 11. Cause-effect-cause diagram on wax blockage

Presents a cause-effect-cause analysis diagram, illustrating how two primary causes, wax impurity and reduced nozzle diameter (due to design for higher accuracy), jointly lead to spout clogging (Fig. 11). These causes are exacerbated by a lack of filtering mechanisms and non-modular design, thus creating a target disadvantage that hampers production efficiency.

4.8. Research implication

This research offers several significant implications for the Batik industry, particularly in enhancing traditional production tools. By implementing TRIZ's Function Analysis alongside other tools, this study provides a structured approach to solving technical contradictions that hinder efficiency in the Batik-making process. The proposed improvements to the canting tool include adding heaters, filters, flow regulators, and modular spouts, optimizing production speed, and reducing labor intensity for artisans. This enables the Batik industry to produce high-quality products more efficiently, potentially lowering production costs and making Batik more accessible to a broader market.

Additionally, the study promotes a mindset of innovation within traditional craft industries, encouraging Batik artisans to adopt systematic problem-solving techniques to improve their tools and processes continually. This approach contributes to the sustainability of the Batik industry, helping artisans maintain competitiveness in a global market where efficiency and quality are paramount. By addressing the limitations of the traditional canting tool, this research also opens pathways for further innovation in other aspects of Batik production, supporting the preservation and growth of Indonesia's cultural heritage in a modern context.

4.9. Comparison of previous research

This study significantly contributes to applying the TRIZ methodology in the Batik industry, particularly in developing a more efficient canting tool. Compared to previous research, primarily focused on product development, sustainability, business management, and services, this study uniquely addresses Batik artisans' technical challenges.

While prior studies successfully integrated TRIZ with various disciplines such as exergy analysis, knowledge management, multi-objective optimization, and service blueprinting, they largely overlooked the specific needs of traditional crafts. This research fills a crucial gap in TRIZ applications for creative and cultural sectors by focusing on the Batik industry.

The proposed innovations, such as integrating a heater, filter, flow regulator, and modular spout, offer concrete solutions to common technical issues, including wax clogging and inconsistent flow. These enhancements improve production efficiency and ensure a more sustainable and user-friendly design for artisans. Unlike previous studies that emphasize theoretical frameworks or focus on industries like renewable energy, packaging, healthcare, and service management, this research addresses practical concerns in Batik production.

Implementing function analysis and TRIZ provides a structured problem-solving approach that systematically identifies and resolves inefficiencies in traditional canting tools. Expanding TRIZ applications to other traditional craft industries could unlock new opportunities for innovation in cultural heritage preservation. By bridging the gap between advanced problem-solving methodologies and artisanal craftsmanship, this study demonstrates the potential of TRIZ to drive meaningful advancements in creative industries, ensuring that traditional practices remain relevant and competitive in the modern era.

5. CONCLUSION

This article summarizes research addressing issues with the canting tool used in Batik production in Giriloyo Village. The study successfully identified that a smaller size for the canting's spout could enhance the accuracy of batik patterns and lead to wax blockage problems due to dirt. Through systematic application of TRIZ methodology, with emphasis on Function Analysis, innovative solutions were developed to resolve this contradiction without compromising the tool's reliability.

This study demonstrated how integrating Function Analysis and TRIZ can lead to tangible design innovations in traditional tools. The core findings include the development of canting modifications, such as heating integration, wax filtering, flow regulation, and modular spout replacement, that directly address the key contradiction of precision vs. reliability. These modifications are feasible and offer meaningful benefits in reducing production time, lowering costs, and improving the consistency and competitiveness of Batik products. This research provides a systematic and replicable innovation model for other creative industries facing similar process inefficiencies.

Unlike prior canting innovations (e.g., US2567960A’s mechanical spout or electric canting prototypes), our TRIZ-driven design resolves the precision-reliability contradiction through modular spouts and feedback-controlled heating, a novel integration of systematic problem-solving with traditional craft tools. Systematic framework for canting tool innovation by combining function analysis and TRIZ, this study established a structured approach to identify design deficiencies (e.g., wax flow control, spout clogging) and propose targeted improvements, offering a replicable model for future tool innovations in traditional crafts. The study demonstrated how principles like merging (integrated heater), beforehand cushioning (filter for dirt prevention), segmentation (modular spouts), and feedback (visual indicators) resolve technical contradictions in canting design without sacrificing functionality, a novel application in the Batik industry.

The proposed modifications (heater, filter, flow regulator, and interchangeable spouts) have the potential to reduce production time, lower costs, and improve product consistency, thereby enhancing Indonesian Batik's competitiveness in global markets. This research provides actionable insights for Batik artisans and SMEs to adopt ergonomic and sustainable tool designs, supporting the long-term viability of Indonesia’s Batik heritage as a creative industry.

This research contributes significantly to the development of more efficient Batik production tools. It opens opportunities for further studies on innovations in other Batik equipment to enhance the sustainability of Indonesia's creative Batik industry. Although this study successfully proposed improvements for the canting tool in Batik production using Function Analysis and TRIZ methods, certain limitations must be acknowledged. For future research, it is recommended that the scope of analysis be expanded to include these external and operational factors. Further exploration into adopting emerging technologies or materials could lead to more robust and adaptable solutions. Additionally, testing the proposed improvements across different Batik production environments and varying scales of operation could provide deeper insights into the model's applicability and effectiveness in diverse industrial contexts.

REFERENCES

[1] M. I. H. Wijaya, T. Fadiyah, H. B. Wijaya, and A. Artiningsih, “Participation of Business Actors in Implementing Circular Economy on Batik Products in Kauman Batik Kampoeng, Pekalongan City,” *Tataloka*, vol. 26, no. 3, pp. 208–217, Aug. 2024, doi: 10.14710/tataloka.26.3.208-217.

[2] W. Handayani, A. I. Kristijanto, and A. I. R. Hunga, “Behind the Eco-friendliness of ‘batik warna alam’’; Discovering the motives behind the production of batik in Jarum village, Klaten,” *Wacana*, vol. 19, no. 1, p. 235, Apr. 2018, doi: 10.17510/wacana.v19i1.673.

[3] I. Moore, “Cultural and Creative Industries Concept – A Historical Perspective,” *Procedia - Soc. Behav. Sci.*, vol. 110, pp. 738–746, Jan. 2014, doi: 10.1016/j.sbspro.2013.12.918.

[4] E. Steelyana, “Batik, A Beautiful Cultural Heritage that Preserve Culture and Supporteconomic Development in Indonesia,” *Binus Bus. Rev.*, vol. 3, no. 1, p. 116, May 2012, doi: 10.21512/bbr.v3i1.1288.

[5] I. K. Subagja, “Creative Industry Competitiveness in Indonesia BT - International Conference “Sustainable

Development Goals 2030 Challenges and Its Solutions",” in *International Conference Sustainable Development Goals 2030: Challenges and Its Solutions*, 2023, pp. 148–176. [Online]. Available: https://www.researchgate.net/publication/334695760
[6] A. S. Putri, S. R. P. Agharli, D. E. P. Wicaksana, and A. Y. N. Sakti, “Towards Sustainable Batik Production: A Green SCM Evaluation and Improvement Recommendations,” *E3S Web Conf.*, vol. 517, p. 06002, Apr. 2024, doi: 10.1051/e3sconf/202451706002.
[7] S. Akhmad, A. Arendra, Mu’alim, K. Winarso, and R. Hidayat, “Design of the mBatik, textile hot wax applicator to emulate hand drawn batik using CNC plotter machine and characterization of wax plotting parameters,” *J. Phys. Conf. Ser.*, vol. 1569, no. 3, p. 032026, Jul. 2020, doi: 10.1088/1742-6596/1569/3/032026.
[8] I. L. Al Qushai, N. K. H. Fernandez, B. Hadisujoto, and S. Tjhin, “Computer numerical control batik machine with automatic conveyor,” in *The Symposium on Advance of Sustainable Engineering 2021 (SIMASE 2021): Post Covid-19 Pandemic: Challenges and Opportunities in Environment, Science, and Engineering Research*, 2023, p. 050090. doi: 10.1063/5.0115809.
[9] S. R. Hidayat, T. B. Affanti, A. I. Josef, and D. Nurcahyanti, “Batik stamp canting made of waste paper material as a frugal innovation in batik,” *IOP Conf. Ser. Earth Environ. Sci.*, vol. 905, no. 1, p. 012125, Nov. 2021, doi: 10.1088/1755-1315/905/1/012125.
[10] M. A. Rasyidi and T. Bariyah, “Batik pattern recognition using convolutional neural network,” *Bull. Electr. Eng. Informatics*, vol. 9, no. 4, pp. 1430–1437, Aug. 2020, doi: 10.11591/eei.v9i4.2385.
[11] R. Syamwil and Kartini, “The economic aspect of batik stamp made of can waste,” *IOP Conf. Ser. Earth Environ. Sci.*, vol. 700, no. 1, p. 012042, Mar. 2021, doi: 10.1088/1755-1315/700/1/012042.
[12] N. Maninggar and D. Hudalah, “Low-Tech Innovation and Local Economic Development: Case Study the Traditional Batik Industry in Pekalongan Municipality,” *Tataloka*, vol. 20, no. 1, p. 1, Feb. 2018, doi: 10.14710/tataloka.20.1.1-11.
[13] A. Syahid, A. M. Fauzi, and A. Ismayana, “Sustainability Investigation of Batik Production at Seraci Batik Betawi,” *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1358, no. 1, p. 012037, Jun. 2024, doi: 10.1088/1755-1315/1358/1/012037.
[14] N. Setyorini, I. Menarianti, P. R. Nastiti, I. Rosidah, and D. A. Dinata, “Training in electrical canting for children with special needs to improve batik quality,” *Abdimas J. Pengabdi. Masy. Univ. Merdeka Malang*, vol. 8, no. 4, pp. 639–648, Nov. 2023, doi: 10.26905/abdimas.v8i4.11232.
[15] I. D. Wulandari and H. Harmayetty, “The Effect of Turmeric Drink and Lavender Aromatherapy Combination on Neck Pain in Batik Craftsmen in Tuban,” *Fundam. Manag. Nurs. J.*, vol. 4, no. 2, p. 50, Oct. 2021, doi: 10.20473/fmnj.v4i2.31357.
[16] V. Ratten, *Entrepreneurship in Indonesia: From Artisan and Tourism to Technology-based Business Growth*. in Routledge Studies in Entrepreneurship. Taylor & Francis, 2021. [Online]. Available: https://books.google.co.id/books?id=cmZCEAAAQBAJ
[17] D. D. Sheu, M.-C. Chiu, and D. Cayard, “The 7 pillars of TRIZ philosophies,” *Comput. Ind. Eng.*, vol. 146, no. 101, p. 106572, Aug. 2020, doi: 10.1016/j.cie.2020.106572.
[18] A. A. Aguilar-Lasserre, V. E. Torres-Sánchez, G. Fernández-Lambert, C. Azzaro-Pantel, G. Cortes-Robles, and M. A. Román-del Valle, “Functional optimization of a Persian lime packing using TRIZ and multi-objective genetic algorithms,” *Comput. Ind. Eng.*, vol. 139, p. 105558, Jan. 2020, doi: 10.1016/j.cie.2018.12.005.
[19] I. Ekmekci and M. Koksal, “Triz Methodology and an Application Example for Product Development,” *Procedia - Soc. Behav. Sci.*, vol. 195, pp. 2689–2698, Jul. 2015, doi: 10.1016/j.sbspro.2015.06.481.
[20] J. C. Alvarez, K. Hatakeyama, M. Carvalho, R. C. Marçal, J. Inche, and N. de Melo, “A model for renewable energy-based product innovation based on TRIZ methodology, exergy analysis and knowledge management: Case study,” *Energy Reports*, vol. 8, pp. 1107–1114, Nov. 2022, doi: 10.1016/j.egyr.2022.07.110.
[21] J.-R. Chou, “A TRIZ-based product-service design approach for developing innovative products,” *Comput. Ind. Eng.*, vol. 161, no. 1, p. 107608, Nov. 2021, doi: 10.1016/j.cie.2021.107608.
[22] D. D. Sheu, M. C. Chiu, and D. Cayard, “The 7 pillars of TRIZ philosophies,” *Comput. Ind. Eng.*, vol. 146, no. 101, p. 106572, 2020, doi: 10.1016/j.cie.2020.106572.
[23] A. A. Aguilar-Lasserre, V. E. Torres-Sánchez, G. Fernández-Lambert, C. Azzaro-Pantel, G.

Cortes-Robles, and M. A. Román-del Valle, "Functional optimization of a Persian lime packing using TRIZ and multi-objective genetic algorithms," *Comput. Ind. Eng.*, vol. 139, p. 105558, Jan. 2020, doi: 10.1016/j.cie.2018.12.005.

[24] J. Delgado-Maciel, G. Cortés-Robles, C. Sánchez-Ramírez, J. García-Alcaraz, and J. M. Méndez-Contreras, "The evaluation of conceptual design through dynamic simulation: A proposal based on TRIZ and system Dynamics," *Comput. Ind. Eng.*, vol. 149, p. 106785, Nov. 2020, doi: 10.1016/j.cie.2020.106785.

[25] V. Souchkov, "TRIZ Developers Summit 2019," 2019. [Online]. Available: http://www.xtriz.com/publications/TDS2019-Souchkov-TRIZ_for_Business_State_of_the_Art.pdf

[26] I. Kose and S. Guner, "A new approach that proposes TRIZ as a creative problem solving technique in health services," *Pressacademia*, vol. 7, no. 2, pp. 67–79, Jun. 2020, doi: 10.17261/Pressacademia.2020.1200.

[27] A.-J. Shie, W.-F. Wu, M. Yang, X. Wan, and H. Li, "Design and process optimization of combined medical and elderly care services: An integrated service blueprint–TRIZ model," *Front. Public Heal.*, vol. 10, no. 1, Oct. 2022, doi: 10.3389/fpubh.2022.965443.

[28] S. Guner and I. Kose, "Creative Problem Solving Technique Application Areas of TRIZ: Suggestions for Use in Healthcare Sector," *Ekon. İşletme ve Maliye Araştırmaları Derg.*, vol. 2, no. 2, pp. 185–208, Aug. 2020, doi: 10.38009/ekimad.763538.

[29] Y.-S. Lin and M. Chen, "Implementing TRIZ with Supply Chain Management in New Product Development for Small and Medium Enterprises," *Processes*, vol. 9, no. 4, p. 614, Mar. 2021, doi: 10.3390/pr9040614.

[30] F. E. Essaber, R. Benmoussa, R. De Guio, and S. Dubois, "A Hybrid Supply Chain Risk Management Approach for Lean Green Performance Based on AHP, RCA and TRIZ: A Case Study," *Sustainability*, vol. 13, no. 15, p. 8492, Jul. 2021, doi: 10.3390/su13158492.

[31] H. Rau, J.-J. Wu, and K. M. Procopio, "Exploring green product design through TRIZ methodology and the use of green features," *Comput. Ind. Eng.*, vol. 180, p. 109252, Jun. 2023, doi: 10.1016/j.cie.2023.109252.

[32] R. Boavida, H. Navas, R. Godina, H. Carvalho, and H. Hasegawa, "A Combined Use of TRIZ Methodology and Eco-Compass tool as a Sustainable Innovation Model," *Appl. Sci.*, vol. 10, no. 10, p. 3535, May 2020, doi: 10.3390/app10103535.

[33] M. A. Mortazavi, A. Amindoust, A. Shahin, and M. Karbasian, "Identification and extraction of factors affecting maintenance strategy selection with 39 parameters of TRIZ approach using meta- synthesis," *J. Crit. Rev.*, vol. 7, no. 10, pp. 2428–2447, 2020, [Online]. Available: https://research.iaun.ac.ir/pd/amindoust/pdfs/PaperM_6901.pdf

[34] M. A. Mortazavi, A. Amindoust, A. Shahin, and M. Karbasian, "Integration of the TRIZ Matrix and ANP to Select the Reactive Maintenance Tactics Using the Meta-Synthesis Approach," *Manag. Prod. Eng. Rev.*, vol. 12, no. 1, pp. 108–118, Mar. 2021, doi: 10.24425/mper.2021.136876.

[35] D. Russo and C. Spreafico, "TRIZ-Based Guidelines for Eco-Improvement," *Sustainability*, vol. 12, no. 8, p. 3412, Apr. 2020, doi: 10.3390/su12083412.

[36] V. Sojka and P. Lepší-k, "Use of TRIZ, and TRIZ with Other Tools for Process Improvement: A Literature Review," *Emerg. Sci. J.*, vol. 4, no. 5, pp. 319–335, Oct. 2020, doi: 10.28991/esj-2020-01234.

[37] G. Guarino, A. Samet, and D. Cavallucci, "PaTRIZ: A framework for mining TRIZ contradictions in patents," *Expert Syst. Appl.*, vol. 207, p. 117942, Nov. 2022, doi: 10.1016/j.eswa.2022.117942.

[38] P. Shao, R. Tan, Q. Peng, L. Zhang, K. Wang, and Y. Dong, "Problem-Solving in Product Innovation Based on the Cynefin Framework-Aided TRIZ," *Appl. Sci.*, vol. 12, no. 9, p. 4157, Apr. 2022, doi: 10.3390/app12094157.

[39] J. Chrząszcz, "Using TRIZ to Write a Good Thesis on Time," vol. 682, 2023, pp. 393–404. doi: 10.1007/978-3-031-42532-5_30.

[40] S. Lu, Y. Guo, W. Huang, and M. Shen, "Product Form Evolutionary Design Integrated with TRIZ Contradiction Matrix," *Math. Probl. Eng.*, vol. 2022, pp. 1–12, Jun. 2022, doi: 10.1155/2022/3844324.

[41] Y. Borgianni, L. Fiorineschi, F. S. Frillici, and F. Rotini, "The process for individuating TRIZ Inventive Principles: deterministic, stochastic or domain-oriented?," *Des. Sci.*, vol. 7, no. 2013, p. e12, Jun. 2021, doi: 10.1017/dsj.2021.12.