

Digitalization of Design in Laweyan Batik Craft Center, Surakarta

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ABSTRACT: This research examines the implementation of design digitalization in the Laweyan batik craft center in Surakarta, Indonesia, as an effort to preserve intangible cultural heritage while enhancing the competitiveness of the batik industry in the era of Industrial Revolution 4.0. Kampung Batik Laweyan, which has existed since the 16th century, faces modernization challenges that demand digital transformation in design and product marketing processes. The research methodology employs a qualitative descriptive approach with data collection techniques through observation, in-depth interviews, and documentation studies. The research findings indicate that design digitalization in Laweyan encompasses three main aspects: the use of Computer-Aided Design (CAD) for motif creation, implementation of Computer Numerical Control (CNC) technology in the waxing process, and utilization of digital marketing platforms for market expansion. Research findings suggest that digital technology integration does not eliminate the philosophical values and aesthetics of traditional batik, but rather enriches design variations and increases production efficiency. This study provides theoretical contributions to understanding the harmonization between tradition and technology in the context of cultural heritage preservation, as well as practical implications for developing creative industries based on local wisdom in Indonesia.

KEYWORDS: Digitalization, Batik Design, Laweyan, Cultural Heritage, Industrial Revolution 4.0, Computer-Aided Design

I. INTRODUCTION

Indonesian batik is an intangible cultural heritage recognized by UNESCO on October 2, 2009, as a Masterpiece of Oral and Intangible Heritage of Humanity. This recognition affirms batik's position as a symbol of Indonesia's cultural richness imbued with philosophical meanings and social values (Nuringsih et al., 2021; Tumanggor & Sazali, 2025). This international recognition also emphasizes batik's position as Indonesia's cultural identity with profound philosophical, aesthetic, and social values (Doellah, 2002). The techniques, symbolism, and culture surrounding cotton and silk batik fabric manually colored have permeated Indonesian society from birth to death. Babies are carried in batik cloth adorned with symbols designed to bring fortune, and corpses are shrouded in burial batik with spiritual meaning. Nevertheless, the existence of this batik art faces serious challenges from foreign cultural influences and globalization currents, threatening its preservation and authenticity (Priyanto, 2023).

Kampung Batik Laweyan Surakarta is one of Indonesia's oldest batik centers with a batik history dating back to the Pajang Kingdom era around 1546. As a batik production center, Laweyan has been a silent witness to the development and evolution of Indonesian batik, from oral tradition to adaptation to modern technology, as well as facing globalization challenges impacting economic and cultural sustainability (Poon, 2020). Therefore, design digitalization becomes crucial for maintaining Laweyan batik's relevance in the global market while preserving its traditional motif richness (Kembang et al., 2025). Historical data shows that Laweyan has stood as a hand-drawn batik production center introduced by Kyai Ageng Henis in the early 16th century. Since then, Surakarta batik has been synonymous with Laweyan because this is where batik originated and has been produced generationally. This 24-hectare area features various historical buildings with a blend of Javanese, European, Chinese, and Islamic architecture surrounded by high walls, reflecting the prosperity of batik merchants during their heyday. This phenomenon reflects how Laweyan batik is not merely a commercial product but also a representation of local wisdom and symbolic expression facilitating architectural and social preservation of its community (Poon, 2020). However, the Laweyan batik industry has experienced dynamic ups and downs heavily influenced by national and global political and economic conditions. For example, the batik industry's decline in the late 20th century (Widodo & Putra, 2024). A significant decline period occurred when printing technology from China was introduced to the textile industry, causing batik craftsmen to lose customers and livelihoods. This dark period lasted from the 1980s until 2004. Factors such as the emergence of printing technology in the 1970s, economic crises, and lack of regeneration contributed to the Laweyan batik industry's decline in the late 20th century (Widodo & Putra, 2024). Nevertheless, Laweyan's history records its transformation from a farming village to a lawe trading center, raw cotton material,

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supplying the Pajang Kingdom, demonstrating its community's adaptive capacity (Pradipta & Prasetyo, 2021). Due to this important history, revitalization of Kampung Batik Laweyan is now being carried out through renovation of old houses that previously had a major role in batik development in Solo City.

The Industrial Revolution 4.0 era brings new challenges and opportunities for the traditional batik industry. This fourth industrial revolution is characterized by advanced digital technology integration such as the Internet of Things, artificial intelligence, and additive manufacturing, fundamentally changing production, distribution, and product consumption methods, including in the batik craft sector (Hariani & Sutrisno, 2020). The introduction of these technologies opens the way for batik design digitalization, enabling craftsmen to innovate while maintaining authentic traditional motifs. Digital transformation in the textile industry enables manufacturers to maintain traditional arts while dramatically improving operational performance. In this context, batik design digitalization becomes one of the key strategies for maintaining Laweyan batik industry's relevance and competitiveness in the global market.

The Laweyan Batik Village Development Forum (FPKBL), since its establishment, has actively promoted and preserved Laweyan batik, including initiating Kampung Batik Laweyan as a tourist destination in 2004 (Basworo & Sujadi, 2018; Chrisnayani, 2009). This effort is a response to the degradation experienced by the Laweyan area after the batik glory period ended, demonstrating an adaptive strategy for economic recovery and cultural preservation (Chrisnayani, 2009). This vision reflects the Laweyan batik community's awareness of the importance of adopting digital technology without abandoning traditionally inherited values. This research aims to comprehensively examine the implementation of design digitalization in the Laweyan batik craft center, analyze its impact on cultural heritage preservation, and identify opportunities and challenges faced in the digital transformation process. Based on the background outlined above, the research problem formulation is: (1). How is batik design digitalization implemented in the Laweyan Surakarta craft center? (2). What is the impact of design digitalization on preserving traditional batik's philosophical values and aesthetics? (3). How is the integration strategy of digital technology with traditional batik-making processes in Laweyan? (4). What opportunities and challenges do Laweyan batik craftsmen face in adopting digital technology?

II. LITERATURE REVIEW

A. *Batik as Indonesian Intangible Cultural Heritage.*

Batik plays a multidimensional role in Indonesian culture (Kusrianto, 2013). It is a coloring technique using wax as a color resist (Djoemena, 1990). On October 2, 2009, UNESCO inscribed hand-drawn batik and stamped batik as Indonesia's Masterpiece of Oral and Intangible Heritage of Humanity. Since then, Indonesia has celebrated National Batik Day every October 2nd. UNESCO highlights three aspects in recognizing Indonesian batik: manufacturing techniques, symbolism, and culture surrounding Indonesian batik that permeates Indonesian society's life (Steelyana, 2012). Knowledge of batik-making has been passed down from generation to generation, from design, motifs, to the coloring process (Hasanudin, 2001). This craft is introduced from baby birth when a mother uses batik-patterned baby accessories to carry her child, and is also found in other ceremonies such as weddings, circumcision ceremonies, and funerals (Wulandari, 2011). Batik in Java transcends mere aesthetics; it functions as a visual language reflecting the island's diverse cultural heritage (Hitchcock, 1991). Intricate batik patterns, varying from the geometric precision of Yogyakarta batik to the floral elegance of Solo batik, tell stories of royal palaces, ancient folklore, and nature (Veldhuisen, 2007). Each motif carefully applied using hot wax as a color resist carries symbolic weight, communicating social status, regional identity, and personal narratives (Achjadi, 1999).

B. *History and Development of Kampung Batik Laweyan*

Kampung Batik Laweyan has been Solo's batik icon since the 19th century, when the first Islamic Trading Association was founded by Haji Samanhudi in 1912 (Priyatmono, 2012). Solo batik history is believed to originate from Laweyan, first introduced during the Pajang Kingdom era by Kyai Ageng Henis in the early 16th century. Thus, Surakarta batik is Laweyan. From Pajang, batik flowed following the Laweyan River, entering the Bengawan Solo River and continuing to the Java Sea, giving birth to coastal batik motifs (Doellah, 2002). The dynamics of the Laweyan batik industry have always been intertwined with state political dynamics, from colonial times to Indonesia's independence era (Setiawan, 2010). During the first colonial period, Laweyan was always tightly controlled by the Dutch colonial government, especially since Kyai Samanhoedi formed a resistance organization called the Islamic Trading Association (Ricklefs, 2001). Currently, Laweyan has 250 patented batik motifs. Unlike Kauman batik with dark colors and classic motifs, Laweyan batik offers batik with brighter colors (Mlayadipura, 2018). Laweyan gradually developed into a tourist destination based on residents' collective capacity, especially in batik and tourism (Supriyadi et al., 2016). Considering heritage as valuable cultural knowledge and regional economic development strategy, Laweyan leverages local cultural heritage's economic potential in its tourism marketing (Purnomo, 2016). On January 7, 2013, Laweyan received the Upakarti award presented by President Susilo Bambang Yudhoyono for the pioneer category in transforming Laweyan not only as a batik village but also as a cultural heritage area.

C. *Industrial Revolution 4.0 and Digital Transformation of the Textile Industry*

Industry 4.0 revolutionizes textile manufacturing by integrating cutting-edge technologies such as IoT, Big Data Analytics, AI, robotics, digital twins, and blockchain into production processes (Schwab, 2016). This digital revolution transforms conventional fabric manufacturing into a sophisticated, data-driven ecosystem where smart factories and automation become the new norm (Kagermann et al., 2013). Digital transformation in textiles involves enhancing traditional manufacturing processes to include real-time data collection, automation, and analytics driving efficiency and innovation (Prasetyo & Sutopo, 2018). For sectors with mass production like the textile industry, transition to a circular economy is essential (Bertola & Teunissen, 2018). Incorporating Industry 4.0 concepts into the textile industry implies readiness for rapid shifts from analog to digital and virtual technologies and trends (Rangaswamy et al., 2020). Other Industry 4.0 factors have significantly transformed the traditional textile industry: remote factory monitoring and maintenance, automated supply chains, virtual trade shows and product showrooms, direct-to-consumer business models, utilization of big data and machine learning, AR/VR, IoT use in factories, additive manufacturing, and cybersecurity.

D. *Computer-Aided Design (CAD) in Batik Design*

Batik's popularity reflects consumer demand for purchase fulfillment (Pujiyanto, 2019). Digital technology can bring several advantages and new opportunities in custom batik design processes (Hariadi et al., 2013). Computer-Aided Design (Prasetyo & Singgih, 2018). CAD systems for batik design are developed to provide services such as pattern customization in various sizes, batik character input systems, pricing, and production time estimation that can be used by batik industries in Indonesia and can be directly forwarded to manufacturing processes (Lukman et al., 2014). Development of CAD/CAM-based automatic batik tjanting prototypes is a common study in Indonesia (Triyanto et al., 2018). A larger batik community, abundance of distinctive regional motifs, and Indonesian batik's declaration as intangible cultural heritage may have driven Indonesia to make further commitments in digital identification and preservation of its batik motifs (Mulyanto, 2020). Adoption of computer-based technologies such as Computer Numerical Control.

E. *Fractal Batik and jBatik Software*

Fractal Batik is an innovation integrating traditional batik art with modern technology through applying fractal mathematical formulas to create more complex and innovative batik designs (Hariadi et al., 2013). This technology is developed through jBatik software enabling more efficient design and production processes without sacrificing batik's aesthetic and philosophical values as cultural heritage (Lukman et al., 2014). Batik and fractals are two different concepts: batik is in the art realm, while fractals are mathematical concepts discussing iteration and self-similarity (Mandelbrot, 1983). However, batik and fractals merge into a concept in a new batik type: Fractal Batik (Hariadi & Lukman, 2007). jBatik software is software for designing batik motifs using fractal methods (Lukman et al., 2014). Fractals themselves are mathematical science related to repetition (Mandelbrot, 1983). With jBatik, craftsmen can develop modular batik motifs and create new compositions in various variations. This software offers features facilitating precise curve adjustment, spacing, and size. Algorithms for creating Fractal Batik have been developed into software known as jBatik, which becomes a tool for batik makers to create new patterns.

F. *CNC Technology in Batik Production*

Butimo : CNC-based hand-drawn batik machines (Triyanto et al., 2018). The CNC-based Butimo machine replaces the klowongan process. This machine's main function is to automatically produce batik patterns on fabric, mimicking batik maker hand movements in the canting process with high accuracy (Wibisono et al., 2016). Using this CNC technology enables faster and more consistent batik production, overcoming human labor limitations and increasing production efficiency (Dwinugroho et al., 2019). The Butimo hand-drawn batik machine's presence is not to replace the entire manual batik process but aims to improve quality and production processes while maintaining hand-drawn batik essence to compete with printed batik. This approach aims to make the batik process faster and more cost-effective, making batik more competitive in the market.

III. METODOLOGY

A. *Research Approach and Type*

This research uses a descriptive qualitative approach to examine batik design digitalization phenomena in Kampung Batik Laweyan comprehensively and in-depth (Creswell, 2014). The qualitative approach was chosen because it allows researchers to understand sociocultural contexts, technology transformation processes, and batik industry actors' experiences in adopting digital technology (Moleong, 2017). The research strategy used is an embedded single case study (Yin, 2018).

B. *Research Location and Time*

The research was conducted in Kampung Batik Laweyan, Laweyan Sub-district, Laweyan District, Surakarta City, Central Java. This location was chosen because it is one of Indonesia's oldest batik centers with more than four centuries of batik history and has implemented various digitalization initiatives in its industrial development.

C. *Data Sources and Data Collection Techniques*

Research data sources include informants, places and events, and documents (Sugiyono, 2019). Research informants consist of batik craftsmen, batik business owners, and administrators of the Laweyan Batik Village Development Forum. Data collection techniques include: (1) Participatory observation of batik production processes and digital technology use; (2) In-depth interviews with key informants; (3) Documentation studies including policy documents, statistical data, and Laweyan historical archives; and (4) Focus Group Discussions (FGD) with batik craftsmen communities.

D. *Data Analysis Techniques*

Data analysis uses an interactive analysis model consisting of three components: data reduction, data presentation, and conclusion drawing/verification (Miles et al., 2014). Source triangulation and method triangulation are used to validate research findings. Javanese cultural approaches are also used as interpretive frameworks to understand philosophical values contained in traditional Laweyan batik motifs.

IV, DISCUSSION

A. *Profile of Laweyan Batik Craft Center*

Kampung Batik Laweyan is the oldest batik center in Surakarta City with a batik history spanning more than four centuries. This area has been designated as a cultural heritage site and has become a cultural tourism destination attracting both domestic and international tourists. Currently, there are approximately 90 small and medium batik enterprises operating in Laweyan, producing various types of batik from classic motifs to contemporary designs. Nevertheless, this center faces challenges of batik maker regeneration and the need to adapt to digital technology to maintain the batik industry's relevance in the future (Utomo & Yulia, 2018). Building architecture in Laweyan has unique characteristics with a blend of Javanese, European, Chinese, and Islamic styles reflecting batik merchant prosperity in the past. High walls and narrow alleys are distinctive characteristics of Kampung Batik Laweyan forming specific urban spaces. The magnificence of native batik traders of the past, commonly called "Gal Gendhu," can be seen from their magnificent house heritage (Mlayadipura, 2018). Conservation efforts have been carried out on 30 historical buildings in Laweyan with budget support from the Ministry of Public Works and Public Housing and city government (Supriyadi et al., 2016). The Laweyan Batik Village Development Forum (FPKBL) in developing batik culture introduces batik culture adapted to Javanese traditions, starting from early childhood (Saddhono et al., 2019). This strategy reflects systematic efforts to instill love and understanding of batik heritage from an early age, ensuring sustainability and human resource regeneration in the batik industry (Utomo & Yulia, 2018).



Figure 1: Secretariat of the Laweyan Batik Village Development Forum (FPKBL) located in the center of Kampung Batik Laweyan Surakarta. (Photo: Aan Sudarwanto, 2025)

This Forum's role is also crucial in encouraging innovation, including adopting design digitalization, to maintain Laweyan's competitiveness in the global market while preserving local cultural values (Harsanto & Permana, 2020; Rifani, 2025). Application of digital technology in batik design is expected to expand market reach and attract younger generations while respecting the richness of traditionally inherited motifs (Poon, 2020).

B. *Implementation of Computer-Aided Design (CAD) in Batik Design*

CAD technology adoption in the Laweyan batik industry has changed how craftsmen create new motifs (Prasetyo & Singgih, 2018). CAD systems enable designers to create, modify, and store batik motif designs digitally with high precision. Several advantages of CAD use in Laweyan batik design include: First, time efficiency in the design process (Hariadi et al., 2013). Motif creation that previously required weeks manually can now be completed in hours using CAD software. Digital

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application use can increase productivity by significantly reducing motif creation time. From one design already made, craftsmen can create various design variations without limits by changing provided parameters (Lukman et al., 2014). Second, ability to document and store all batik motifs digitally. Design digitalization enables a motif library that can be easily accessed and modified by designers. This is very important considering Laweyan has 250 patented batik motifs that need to be preserved and developed (Mlayadipura, 2018). Third, integration with manufacturing processes (Prasetyo & Singgih, 2018). Designs produced from CAD systems can be directly forwarded to manufacturing processes using CNC hand-drawn batik machines automatically. The Batik 4.0 System has been developed to integrate design and manufacturing systems into one batik production system that can be controlled, integrated, and accessed remotely via the internet using cloud-based technology.

C. Utilization of jBatik Software and Fractal Technology

Batik software has been introduced to the Laweyan batik community as a tool to create batik motifs with a fractal mathematics approach (Hariadi et al., 2013). This technology enables craftsmen to produce complex patterns inspired by traditional motifs but with richer variations. jBatik implementation in Laweyan shows several important characteristics (Hariadi & Lukman, 2007). First, this software facilitates creative exploration through mathematical parameter manipulation producing motif iterations with various complexity levels. Craftsmen can adjust variables such as rotation angles, repetition scales, and pattern density to produce unique visual compositions. Second, jBatik enables preservation of traditional motif philosophical essence while presenting contemporary interpretations (Saddhono et al., 2019). Classic motifs such as parang, kawung, and truntum can be transformed into new variants without losing their symbolic meaning. The research results demonstrate that younger artisans in Laweyan exhibit greater adaptability to jBatik utilization compared to their senior counterparts (Pujiyanto, 2019). This indicates the potential for batik industry regeneration through technology-based approaches that resonate more effectively with millennial and Generation Z cohorts (Rangaswamy et al., 2020). Training programs on jBatik usage, alongside other software applications including Photoshop, CorelDraw, and Canva, have been conducted by FPKBL in partnership with higher education institutions and digital creative communities.



Figure 2: Digital training conducted by FPKBL in collaboration with ISI Surakarta, enabling young Laweyan craftsmen to become more adaptive to digital technology (Photo: Aan Sudarwanto, 2025)

D. Implementation of CNC Technology in the Waxing Process

Computer Numerical Control (CNC) technology (Triyanto et al., 2018). CNC-based hand-drawn batik machines like Butimo (Widodo, 2019). This technology implementation presents a new paradigm in batik production combining mechanical precision with handicraft touch (Prasetyo & Singgih, 2018). The batik production process with CNC technology in Laweyan follows an integrated workflow (Mulyanto, 2020). Motif designs created using CAD software are converted to formats readable by CNC machines through Computer-Aided Manufacturing software (Triyanto et al., 2018). Research findings reveal that CNC technology use can increase production capacity up to five times compared to manual methods (Widodo, 2019). However, Laweyan craftsmen still maintain isen-isen processes (Handayani et al., 2017). This hybrid approach ensures that produced batik still has handmade character which is the main value of hand-drawn batik, while increasing efficiency in repetitive production stages (Pujiyanto, 2019).

E. 4.5 Digital Marketing and Market Expansion

Digital transformation in Laweyan not only occurs in design and production aspects but also includes marketing strategies. Digital marketing platform adoption, such as social media and marketplaces, has opened new opportunities for Laweyan batik MSMEs to reach wider consumers globally, transcending traditional geographical boundaries (Asri et al., 2025;

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Kembang et al., 2025). Laweyan batik craftsmen have adopted various digital marketing platforms to expand their market reach. E-commerce, social media, and websites have become main channels in marketing batik products to national and international markets (Rangaswamy et al., 2020). Some implemented digital strategies include: utilization of marketplaces such as Tokopedia, Shopee, and Bukalapak for business-to-consumer sales. Additionally, digital training and mentoring are conducted to enhance digital skills while also expanding digital insights of Laweyan Surakarta batik village craftsmen.



Figure 3: Digital mentoring conducted by one of the universities in Surakarta for Kampung Batik Laweyan craftsmen is one of FPKBL's strategies in developing Kampung Batik Laweyan (Photo: Aan Sudarwanto, 2025)

Data from FPKBL shows significant sales increases through digital channels since 2020. The COVID-19 pandemic became a catalyst accelerating digital marketing adoption among Laweyan craftsmen (Ministry of Industry, 2021). Business units that previously relied on direct sales in showrooms and physical exhibitions were forced to switch to digital platforms. This transformation opened new market access, including consumers from outside Java and export markets to ASEAN countries, Japan, and Europe (Purnomo, 2016).

F. Impact of Digitalization on Preserving Batik Philosophical Values

One main concern in the digitalization process is the potential loss of traditional batik's philosophical values and aesthetics (Saddhono et al., 2019). Analysis of digitalization implementation in Laweyan shows that technology integration can actually strengthen cultural heritage preservation efforts when done with the right approach (Mulyanto, 2020). Design digitalization enables systematic documentation of classic Laweyan motifs at risk of being lost due to lack of craftsman regeneration (Nurainun et al., 2008). The digital batik motif library developed by FPKBL contains complete information about each motif, including name, philosophy, history, and manufacturing technique. This digital documentation becomes a valuable reference for future generations and cultural researchers (Steelyana, 2012). This research found that CAD and jBatik technology use does not eliminate traditional creative processes but rather becomes an extension of designer capabilities (Hariadi et al., 2013). Batik philosophical values remain preserved because motif conceptualization still originates from deep understanding of symbolic meanings and Javanese cultural contexts (Kusrianto, 2013). Technology only functions as a tool to realize these concepts more efficiently and precisely (Lukman et al., 2014).

G. Digitalization Challenges and Opportunities

Design digitalization implementation in Laweyan faces various challenges (Pujiyanto, 2019). First, digital literacy gaps between craftsman generations create resistance to new technology adoption (Rangaswamy et al., 2020). Senior craftsmen who have mastered traditional techniques for decades tend to be skeptical about digital technology effectiveness. Second, limited technology infrastructure and uneven internet access hinder integrated system implementation. Third, initial investment for CAD/CNC hardware and software requires significant capital, becoming an obstacle for micro and small business units (Handayani et al., 2017). Fourth, there are concerns about excessive standardization that can reduce individual uniqueness of each batik work (Saddhono et al., 2019). Traditional hand-drawn batik is valued precisely for imperfections and subtle variations reflecting batik maker hand touch (Doellah, 2002). CNC machine use potentially produces overly uniform products thus losing artisanal character (Widodo, 2019). On the other hand, digitalization opens great opportunities for Laweyan batik industry development (Prasetyo & Sutopo, 2018). Increased production efficiency enables craftsmen to fulfill large orders in shorter time (Triyanto et al., 2018). Richer design variations through digital exploration expand market segmentation (Hariadi et al., 2013). Access to global markets through digital marketing platforms increases export potential (Mulyanto, 2020). Industry regeneration through involving tech-savvy younger generations ensures batik tradition sustainability (Pujiyanto, 2019).

V. CONCLUSION

Based on research results and discussion, several important conclusions can be drawn regarding design digitalization in the Laweyan Surakarta batik craft center. First, design digitalization implementation in Laweyan encompasses three integrated main aspects: Computer-Aided Design use for motif creation, Computer Numerical Control (CNC) technology implementation in the waxing process, and digital marketing platform utilization for market expansion. Second, digital technology integration does not eliminate Laweyan traditional batik's philosophical values and aesthetics. Digital documentation actually strengthens classic motif preservation efforts, while creative exploration through design software enriches motif variations without abandoning cultural essence. The hybrid approach combining automation at certain stages with manual processes at critical stages ensures hand-drawn batik handmade character remains preserved. Third, the harmonization strategy between tradition and technology in Laweyan is built through the principle of "technology as a tool, not a replacement." Local wisdom values and Javanese philosophy remain the foundation in creative processes, while digital technology functions to increase efficiency and expand reach. The "Laweyan Smart Kampung" vision promoted by FPKBL becomes a strategic framework guiding sustainable digital transformation. Fourth, main digitalization challenges include digital literacy gaps, infrastructure limitations, capital investment needs, and concerns about losing artisanal uniqueness. However, opportunities presented such as production efficiency, design diversification, global market access, and industry regeneration provide positive prospects for Laweyan batik industry sustainability in the Industrial Revolution 4.0 era.

Based on research findings, several recommendations are formulated for developing Laweyan batik industry based on digital technology. First, structured and sustainable digital literacy training programs need to be developed for batik craftsmen from various generations. This program should use andragogy approaches considering adult learning characteristics and local cultural contexts. Second, local and central governments need to provide technology infrastructure support and special financing schemes for CAD/CNC technology adoption by micro and small business units. Partnerships with universities and research institutions can accelerate technology transfer and development of solutions suitable for local needs. Third, quality standards development is needed to accommodate batik products from digital technology while still appreciating traditional hand-drawn batik uniqueness. Clear certification and labeling systems will help consumers understand differences between various batik product categories. Fourth, collaboration between Laweyan batik community with digital creative communities, technology startups, and e-commerce platforms needs to be enhanced to optimize digital market potential. Inclusive digital ecosystem development will strengthen Laweyan batik industry competitiveness at national and global levels.

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