

# Popularize Mathematics with Crystallography Batik and Batima

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## Abstract

This paper shows efforts to popularize mathematics through batik culture in Indonesia. There are 2 classifications of batik used here, i.e. batik whose motif follows the symmetry of crystallography, and batik with motifs designed from algebraic surfaces called Batik Innovation of Mathematics (Batima). Crystallography motifs are made from 1 design as a motif and it can be generated into several motifs designed from one stamp batik. While the Batima motif is made from algebraic equations. This paper only shows a few examples of Batima with algebraic equations made in stamps

batik. Some derivative products such as bags, masks, accessories, and key chains can also be made. In order for this batik to become part of the popularization of mathematics, promotional efforts are carried out using various existing promotional media. The promotion has been carried out since 2019 by creating blogs, exhibitions, and existing social media such as YouTube, web, shop marketplace, following competitions, and presenting at conferences. In 2023, the university has collaborated with a home industry called Nilo Tirta to develop varied motif designs and be produced on a limited scale. Furthermore, promotion and branding efforts for crystallographic batik and mathematical innovation batik products can be carried out in a sustainable manner.

**Keywords:** Crystallography, Mathematical, Innovation, Batik, Sustainable

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## 1. Introduction

The development of digital technology in the learning process can cause an acceleration that occurs in all aspects of life(Okoye et al., 2021; Mia et al., 2019) (Dabića et al., 2023; Farooq et al., 2013; Mourabet et al., 2017; Shen ET AL., 2022). Similarly, mathematics learning is not spared from various technologies that have developed. Utilization in various fields is carried out to be able to show the role of mathematics in many fields so that mathematics(Attard & Holmes, 2020; Ismail & Azha, 2018; Yan et al., 2018 ; Kovačević et al., 2021) can be of interest to every young generation in a sustainable manner, especially in Indonesia. Moreover, the learning situation after the COVID-19 pandemic, the use of technology is needed in the sustainability of mathematics learning in the industrial revolution 4.0 (Naidoo & Reddy, 2023; Kongkiatpaiboon et al., 2017). Similarly, mathematics also develops simultaneously due to the learning and research process in it as has been researched in China(Zhao et al., 2023; Ahmadi et al., 2005; Rahayuningsih et al., 2020; Mia et al., 2022; Ghaemi et al., 2017). One of the efforts made in combining mathematics with the use of digital technology is to utilize mathematics in batik design which is one of the cultural expressions that can be used as fashion that has symbolic meaning and high aesthetic value for the people of Indonesia. The uniqueness and beauty of batik is one of the

shapers of the nation's character that distinguishes the batik products that we have from other nations so that they can become the identity and identity of the nation. This effort was made to popularize mathematics more easily to the Indonesian people by making mathematics part of the products commonly used by the Indonesian people, namely batik (Parhusip et al., 2021; Parhusip et al., 2023; Elibol, 2004).

Batik developed due to the role of mathematics in motif design has been developed in Indonesia. Usually, people know batik with mathematics based on fractal motifs (Hariadi et al., 2013; Makadia & Nanavati, 2013; Rashid et al., 2011). This paper proposes batik with crystallography design and batik innovation of mathematics (Batima). These batiks were developed to popularize mathematics through batik culture. With the existence of Crystallography and Batima, it is hoped that people can recognize mathematics as an interesting learning material because of the motifs and shapes that can be used as batik motifs. In addition, the obtained motifs can also be used on various objects that can be used such as bags, accessories, and souvenirs.

Batik is an Indonesian cultural heritage that needs to be preserved, but batik craftsmen, especially Nilo Tirto who is in the city of Solo, Central Java, face limited motif design constraints and the high price of a stamp because one stamp only produces one batik pattern. In this condition, it is important to apply the motif design in the stamp, which can produce many motifs. The innovation of crystallographic motif design provides many choices of batik patterns for consumers and can minimize the initial stamp so that production costs are more efficient. The uniqueness and novelty of crystallography design innovation, namely one crystallographic canting stamp, produces a variety of superior batik patterns. In addition, batik motif design innovations based on mathematical innovations have varied and interesting batik patterns, to increase the competitiveness of batik.

Furthermore, efforts need to be made to increase the competitiveness of crystallography batik and Batima products in the global market and attract consumers to foreign countries. In this case, the marketing branding department will begin to be built through digital channels that aim to build the reputation of the business name, quality, and overall business on the digital platform. There will also be a trademark of crystallography batik. This is what is shown in this article.

## 2. Methodology

The methods carried out include in general are

- a. Compiling crystallography designs that can be realized as batik motifs
- b. Compiling Batima designs that can be realized as batik motif
- c. Strive for the integration of crystallographic and Batima designs into a new motif

product

- d. Carry out motive application activities on the stamp in collaboration with the stamp manufacturer
- e. Making batik stamps by the motifs and stamps that have been obtained through activities with students
- f. Promotion and marketing efforts as entrepreneurial activities

As for the batik production process, it is a production process similar to batik in general. The following is written the process as follows:

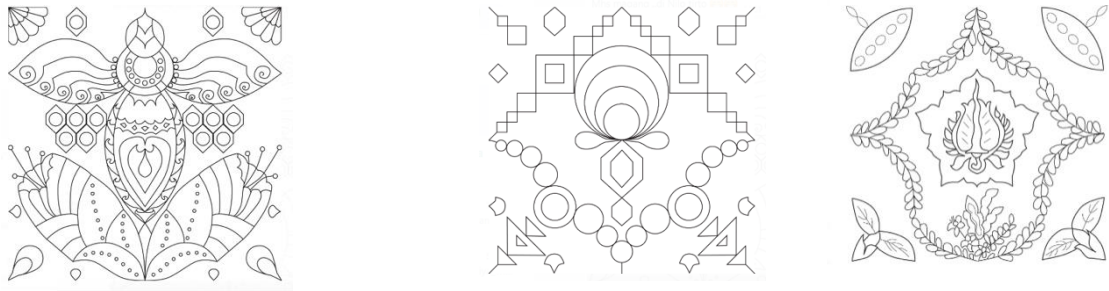
1. The first is *mordanting*, which is boiling mori cloth before another process is carried out to dissolve kanji. After boiling, the cloth is soaked with alum/tunjung water and then dried in the sun to dry.
2. The second is to *nyorek* or make designs on paper to produce crystallographic designs.
3. The third is *ngeblat* or moving the design on mori cloth by involving students involved in MBKM internships.
4. The fourth is *to taste* or make crystallographic patterns that have been designed.
5. The fifth is to *treat* (color) with indigo to produce a dark blue color.
6. In The six stage 1 coloring, the dye is fixed with alum, tunjung, or lime, then dried in the sun, then batik then rotted after drying.
7. The seventh is the *skewness* which includes the stage of taking partial white in order to get some color.
8. Eight soga stainings, with a minimum of 5 to 10 times immersion, more dyeing will produce a nicer and more durable color. In 1 dyeing must first be dried. At this stage, it can be done to produce more colors
9. Ninth Fixation with tuning/alum/lime water
10. Tenth Stage 2 *Rot*, then dried

### 3. Result And Discussion

#### 3.1. Basic Crystallography Ideas and Product Examples

The term crystallography is usually known for complex geometric patterns with shapes that resemble crystal structures. Suppose a pattern of triangles, hexagons, or other polygons creates a pattern reminiscent of the arrangement of atoms in a crystal. While batik is a traditional textile art originating from Indonesia and has distinctive patterns. Batik motifs can reflect various aspects of Indonesian culture and nature (Steelyana, 2012). When we talk about "batik motifs with crystallography," we mean using the crystallography motif with the property of symmetry: that is, the principles of symmetry often found in crystallography, such as oblique symmetry, central symmetry, or rotational symmetry, as the basis for creating interesting batik patterns. This symmetry property was once used by Silk Fabric in obtaining new motifs (Gaitán

et al., 2020). However, keep in mind that batik generally depicts elements such as nature, flora, fauna, or abstract motifs derived from Indonesian cultural traditions. Therefore, batik with crystallography motifs is not a traditional batik motif so batik with crystallography as a new innovation motif where geometric transformations such as shifts and rotations in mathematics are introduced with attention symmetry is either oblique symmetry, central symmetry or rotational symmetry. Some of the motifs that have been acquired in 2023 are shown in Figure 1.



**Figure 1.** Examples of crystallography motifs

In 2022, an application of crystallography batik motif design innovations using crystallography *canting stamp* tools has been granted a patent by the Ministry of Law and Human Rights of the Republic of Indonesia (No.IDS000001908) and granted 13 copyrights on crystallography batik patterns. This activity is the result of research that innovates to make various kinds of unique and creative batik motifs using the concept of symmetry groups. The application of symmetry group theory, namely two-dimensional crystallography, in making motifs on batik stamp fabric. The shape of objects in a flat plane transformed by translational, rotational, reflexive, or glide-reflection generators is replaced with basic motifs. Motifs and products are shown in Figure 2. Furthermore, crystallographic batik motifs are stated in batik stamps processed by students with assistance from Nilo Tirto batik makers, Solo, Central Java as shown in Figure 3.



**Figure 2.** Examples of crystallography batik motifs with their stamps and related batik





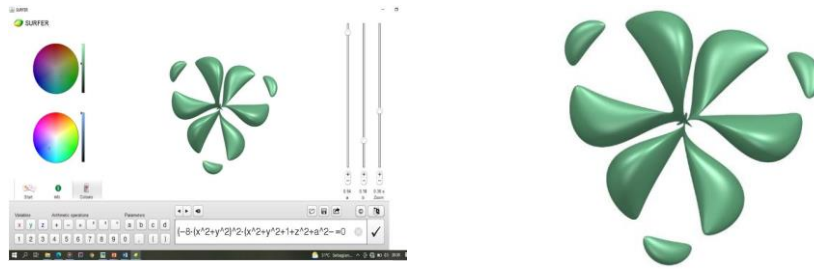
**Figure 3.** The process of making batik stamp is carried out by students in doing internships in Nilo Tirto, Solo city, Central Java, Indonesia.

### 3.2. Basic Batima Ideas and Product Examples

Batima was introduced nationally and widely when Batima was declared as part of innovation in Indonesia at the Indonesian Business Center since 2016. Batima is an art of batik motifs obtained from mathematical formulations such as parametric equations that are expanded with spherical equations to become surfaces and other mathematical operators, namely derivatives or mappings of complex functions imposed on the parametric equation (Parhusip et al., 2021). Similarly, Batima can be produced from variation of algebraic surfaces. Not every obtained motif becomes Batima because the results of the obtained images require batik expertise in making aesthetically appropriate motifs in batik. The obtained forms from mathematical formulas are the basic idea of Batima where the formula does not appear explicitly on batik textiles but becomes a motif on batik textiles. Mathematical derivation and the examples of the products have been discussed in 2018 for a particular motif (Parhusip, 2018)

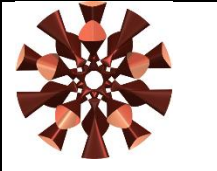
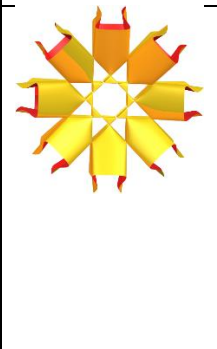
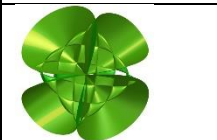
Batik Innovation Mathematics (Batima) is one of the innovations of mathematics by using mathematical formulas or equations that are visualized to be chosen into the motif of a batik. The mathematical formula is visualized with a Surfer software. Examples of selected motifs can be batik motifs shown in

In this section we show some the design results obtained with the software called Surfer which are shown partly. Table 1 propose the obtained form with the Surfer and the equations. Figure 4 shows the Surfer window and the resulting design. In addition to batik fabric, derivative products from batima can be made for various purposes. Figure 7 shows some derivative products such as bags, wallets, masks and seat pillowcases. Silver accessories are described into detail (Parhusip, Nugroho, et al., 2022).

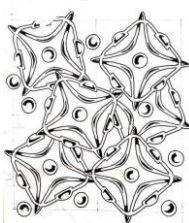


**Figure 4.** The result of the design made with the surfer (left) and the motif model set to be the Batima motif.

**Table 1.** Examples of basic motifs from Batima (column 1) and algebraic equations resulting in images (column 2) created with Surfer software

	$(4*((A*(1+\sqrt{5}))/2)^2*x^2-y^2)*((a*(1+\sqrt{5}))/2)^2*y^2-z^2)*((a*(1+\sqrt{5}))/2)^2*z^2-x^2)-(1+2*(a*(1+\sqrt{5}))/2)*(x^2+y^2+z^2-1)^2*a = 0$
	$z-a*(-1/4*(1-\sqrt{2})*(x^2+y^2)^2+(x^2+y^2)*((1-1/\sqrt{2})*z^2+1/7*(2-7*\sqrt{2}))-z^4+(0.0.) \quad 5+\sqrt{2})*z^2-1/16*(1-12*\sqrt{2}))^2-(\cos(0*3.14/4)*x+\sin(0*3.14/4)*y-1)*(\cos(3.14/4)*x+\sin(3.14/4)*y-1)*(\cos(2*3.14/4)*x+\sin(2*3.14/4)*y-1)*(\cos(3*3.14/4)*x+\sin(3*3.14/4)*y-1)*(\cos(4*3.14/4)*x+\sin(4*3.14/4)*y-1)*(\cos(5*3.14/4)*x+\sin(5*3.14/4)*y-1)*(\cos(6*3.14/4)*x+\sin(6*3.14/4)*y-1)*(\cos(7*3.14/4)*x+\sin(7*3.14/4)*y-1)-z = 0$
	$(-2*a/125+x^8+y^8+z^8-2*x^6-2*y^6-2*z^6+1.25*x^4+1.25*y^4+1.25*z^4-0.25*x^2-0.25*y^2-0.25*z^2+0.03125)*(x^2*y+y^2*z^2+x^2*z^2+x*y*z)*(x^2+y*z^2)=0$

Source: Prepared by the author, (2024)



**Figure 5.** Motif (left) to become stamp (center) with batima motif; the stamp and fabric (right)



**Figure 6.** Crystallography and batima batik results



**Figure 7.** Some derivative products of Batima fabric



**Figure 8.** Keychain products from motifs that can be used other than as batik motifs

### 3.3.Promotion and marketing efforts

Promotional efforts for Batima have been carried out in the last 5 years. Starting from doing exhibitions at universities, or also participating in competitions, also doing promotions using social media such as youtube, web, market places such as shopee and put In some restaurants that provide opportunities for visitors to come directly. Efforts made in 2019 were made by students by creating product blogs (<https://matbis1.wordpress.com/blog/>). Products are made not only motifs for batik but also for ornamental products called Ornament Decorative of Mathematics (Odema). Activities carried out in an effort to popularize Batima and Odema were stated in Tribunnews in 2020 (<https://jateng.tribunnews.com/2020/10/25/odema-dari-rumus-matematika-menjadi-berbagai-suvenir-menarik>). Similarly, television media also popularized nationally on SCTV on October 20, 2020 at 06.20 (<https://www.facebook.com/1376597700/videos/10218951021031294>). Similarly, on



Metro TV television on November 10, 2020, it was shown on Youtube ([https://www.youtube.com/watch?v=qERHjmpi\\_y0](https://www.youtube.com/watch?v=qERHjmpi_y0)). Production activities in entrepreneurial activities in 2020 are also stated in the video so that they can be promoted more broadly ([https://www.youtube.com/watch?v=52ZDLQ\\_fEZA](https://www.youtube.com/watch?v=52ZDLQ_fEZA)). Similarly, entrepreneurial efforts that started from campus have been carried out until now they are still ongoing. An explanation of the above efforts is shown in the literature in detail (Parhusip, Purnomo, et al., 2022) .

### **3.4. Downstream process towards commercialization with branding**

In 2023, activities will be carried out with Nilo Tirto batik makers in Solo to be able to carry out large-scale production and wider marketing. Activities are also supported by government funding from the Ministry of Education and Culture and Technology in the Matching Fund grant. One of the ongoing activities is the presence of students who are also involved in the production process of crystallographic batik and batima. Similarly, production is developed with due regard to products that use natural ingredients. The downstream process towards commercialization of crystallographic batik and batima products with natural dyes is carried out by starting to build early marketing and branding through digital channels. It aims to build business name reputation, quality, and overall business on digital platforms.

The brand building process is carried out in four major stages which at the end will generate Loyalists and Profit. This activity is carried out by universities with internship students, especially from informatics study programs. The first stage is to create a brand blueprint which is done in two steps, namely determining rational value and compiling emotional value. The second stage is to carry out brand delivery promises which are carried out through two numbers, namely: creating visual identity and doing brand communication. The third stage intersects with the fourth stage is the stage of forming brand equity and the stage of delivery proof. There are two stages of this there are four steps, namely the formation of perceptions and expectations, experience giving to distribution channels, products consumed, and reputation. After the four major stages at the end will generate loyalty and profit from the product on an ongoing basis. A schematic of all stages can be seen in Figure 9 of the Branding Journey put forward by The NeymaWay. The role of university is to develop and initiate new channels to be educated to the market through various digital channels as has been done in Batima products with a more massive frequency . Digital channels have tremendous potential and role in building this brand. A number of content in the form of images and videos will be developed for market education needs and disseminated in a structured manner on various digital platforms such as websites, Instagram, Facebook, YouTube, Twitter, and others. These contents will be created using the proposed hardware and device (PC) along with Adobe Creative

Cloud Licenses and Canva Pro image and video processing. Furthermore, PT and partner Nilo Tirto prepare cooperation documents and business plans formally for product commercialization.

#### 4. Conclusion

In this article, batik is shown as Indonesian culture as a product made based on motifs from mathematics called crystallography batik and Batima. These batiks have been part of research that has been done in recent years. However, efforts are still needed to popularize and market this batik so that it becomes a typical Indonesian batik to become a popular product to foreign countries. The existence of crystallographic stamp batik produces batik products with 1 stamp but produces several motifs because this batik has properties that can provide different motifs. Similarly, Batima provides different motifs that give batik uniqueness that cannot be found easily. In this paper are shown some examples of crystallography and Batima both from the initial motifs to made in stamps. In the process of making batik, activities with students are also carried out to be able to involve students involved in the design process to production where business processes can be observed. This indirectly provides learning to students in many aspects. For mathematics students, this activity provides inspiration for how mathematics is applied. In addition, students can learn how to downstream research results in conducting design to become products which then need to be carried out entrepreneurial activities. Students also practice cooperation between the university and batik parties as well as cooperation with students from various different fields. The results obtained still need branding that has not been shown in this article.

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