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Exploration of the Process of Making Batik Sendang Duwur as a Physics Teaching Material on Temperature and Heat

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Abstract

This study explores the concept of physics in local potential, namely hand-drawn batik, by integrating indigenous science with scientific science. The discussion will be related to the physical concepts of temperature and heat transfer at each step or process of making batik, such as heating wax to write batik patterns, dyeing batik cloth, removing batik wax, and drying batik. This research is qualitative research with interview and observation techniques on batik craftsmen in Sendang Duwur Village, Paciran Lamongan. The data analysis technique used refers to the Miles and Huberman model. This study made observations, followed by an exploration of the physics concept of the batik process directly and supported by existing theories. The results of this study there are concepts of physics applied in making Batik Sendang Duwur, especially temperature and heat physics.

Keywords: Batik Sendang Duwur; Ethnoscience; Temperature and Heat

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INTRODUCTION

Physics, as a part of education, science, and technology, can certainly be integrated with the local potential around the school environment. Sahtoni et al. (2017) revealed that the nature of physics is not just a collection of principles, but physics can also discuss how these facts and principles are obtained and how physicists do it. Physics will be very useful for humans if it is realized in science and technology (Bogusevski et al., 2020; Mihardi et al., 2013; Widiyanto, 2018). Learning is expected to focus on students, students no longer only listen to explanations from the teacher, but students must play an active role in learning activities (Fraser et al., 2014; Méndez-Coca, & Slisko, 2013; Prasetyo,

2013). To realize learning following the characteristics of the 2013 curriculum, appropriate facilities and infrastructure are needed, including the presence of media and teaching materials that follow learning objectives and integrating learning materials with local potential in the school environment (Winarti, 2018; Usman, 2019).

Local wisdom is the potential of certain resources owned by an area, both the potential for natural resources, human resources, technology, culture, geography, culture, and history (Augustin, 2018; Hartini et al., 2018; Misbah et al., 2020; Wati et al., 2019). Ogawa (2002) and Snively (2001) also state that indigenous science is related to scientific knowledge obtained through



the culture that is inherent in the area (Sukesti et al., 2019). Harefa (2017) researched learning Physics in schools through the development of ethnoscience; learning needs to be sought to balance scientific knowledge and the values of wisdom that exist in science itself. The process of learning physics is still difficult for students to understand because they usually only use textbooks on the market. Understanding physics material is difficult to achieve because learning material is not associated with something familiar to students, and the learning process does not discuss the existing local potential (Augustin, 2018). Another study also revealed that ethnoscience-based learning would improve student learning outcomes (Anthony, 2017; Usman et al., 2019). One of the local potentials that become the identity of the Indonesian people is batik cloth.

The curriculum analysis also shows that in the 2022/2023 academic year, most schools use two curricula, namely the independent learning curriculum for grades X and XI and the 2013 curriculum for class XII. One of the independent curriculum bills is P5 (Project for Strengthening Pancasila Student Profiles); one of the themes taken at SMAN 2 Lamongan is the project of making hand-drawn batik. Hand-drawn batik itself is one of the local wisdom in Lamongan. Utilization of local potential as a source of learning is one of the characteristics of the existing curriculum; learning science is developed as the application of life skills (Sukesti et al., 2019).

Batik is a textile craft from coloring with wax as a color barrier. Batik is made with batik wax sticks in the form of written canting and canting stamps to form certain motifs that have meaning (Trixie, 2020). Simply, making batik includes making patterns, covering the pattern with wax, coloring, and removing the wax (Setiawan et al., 2018). Every

activity certainly cannot be separated from natural phenomena, whether consciously or not; it is just that we are often focused on what we are doing and our goal without realizing the phenomena that exist in our activities (Harefa, 2019).

Research conducted by Zayyadi (2017) shows that the Madura Batik motif contains applied mathematical concepts in the form of congruence concepts and geometric transformations (Solar et al., 2021). Other studies also discuss processing printed batik waste with chemical techniques (Muljadi, 2013). Agustin (2018) has developed a local potential-based physics module, "Batik Lumbung dan Tahu Plant" and received a very positive response from students.

However, unfortunately, not many studies examine Batik, which is integrated into physics concepts. Research on hand-drawn batik that is integrated into physics is still rarely done. For this reason, this article was made to identify physical concepts in the batik-making process activities on the hand-drawn batik motifs in Sendang Duwur, Paciran Lamongan. The discussion will be related to the physical concepts of temperature and heat transfer at each step or process of making batik, such as heating wax to write batik patterns, dyeing batik cloth, removing batik wax, and drying batik

METHOD

This research is qualitative descriptive research with an ethnographic method which is descriptive field research through an interview and observation process (Spradley, 2006). This study uses a qualitative approach which, when researching field conditions, does not carry out any processing, so the data obtained is only based on existing sources (Sugiyono, 2016). This study uses literature studies, observations, and interviews to collect information related to batik in Sendang Duwur Paciran,

Lamongan area. The informants are five original batik craftsmen from Sendang Duwur Lamongan. The research stages for this research are shown in Figure 1.

According to Spradley (2006), a good informant must have 5 criteria: full enculturation, direct involvement, unfamiliar cultural atmosphere, sufficient time, and non-analytical. Sendang Duwur batik craftsmen as informants will answer all research questions through interviews and observe batik activities from beginning to end. This study uses an unstructured interview technique. The questions asked include the materials used to make hand-drawn batik (, the tools used to make hand-drawn batik, the patterns included in the hand-drawn batik, the philosophy of the

hand-drawn batik pattern, the process or steps for making hand-drawn batik, the time it takes to produce batik and others. The interview rubric is shown in Table 1.

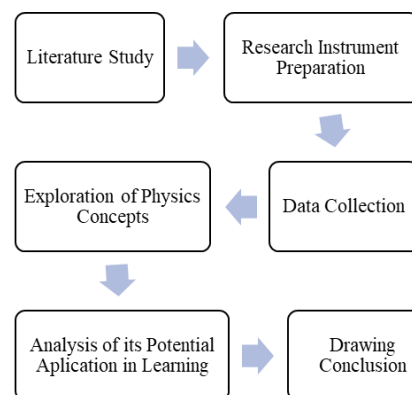


Figure 1 Research stages (Rizki et al., 2022)

Table 1 Interview instrument

No	Aspect	Question
1	History	How did the Sendang Duwur hand-drawn batik originate, then why did the community become hand-drawn batik craftsmen?
2		What makes Sendang Duwur hand-drawn batik different from other hand-drawn batik?
3		Does Sendang Duwur Hand-drawn batik have a distinctive motif?
4		Is there a meaning for each motif in Sendang Duwur Hand-drawn batik?
5	Implementation	What are the tools and materials needed to make Sendang Duwur hand-drawn batik?
6		What are the motifs of the Sendang Duwur hand-drawn batik?
7		What is the process of making Sendang Duwur Batik from start to finish?
8		What are the obstacles in the process of making Sendang Duwur Batik?
9		How long does it take for the process of making Sendang Duwur Batik?
10		Is there a special technique for making Sendang Duwur Batik?
Finding:		

The results are in handwritten diaries, stories, photos, and batik made by batik artisans. During the observation and interview activities, the researcher wrote the collected diaries into a file and then

analyzed them. This study uses data analysis techniques that refer to the Miles and Huberman model (Sugiono, 2016).

The data analysis technique is the process of systematically studying and

organizing data obtained from interviews, making field notes and documents by organizing data into list data, describing, selecting important categories, and drawing conclusions to make it easier for yourself and others. Talk about analyzing qualitative research data before entering the field, during fieldwork, and finishing. Before the searcher enters the search object area, the researcher prepares data or secondary preliminary research data to determine the direction of the research. Then in the course of field research must analyze every person interviewed and be able to give a conclusion; if the data is not yet valid, the researcher can develop questions to a certain level.

RESULT AND DISCUSSION

From the results of observations and interviews with batik craftsmen in Sendang Duwur Village, Paciran District, Lamongan Regency, namely Mrs. Mutrikah, Sendang Batik is a typically hand-drawn batik of Sendang Duwur, which is done traditionally with the medium of malam (wax), canting, and dyes. Informants said this batik is an ancestral heritage passed down from generation to generation. Around the 15th century, Dewi Tilarsih, the wife of Raden Noer Rochmat, known as Sunan Sendang, was considered a pioneer because she had introduced and brought the batik tradition from her native region, namely Mantingan.

Batik from each region has different characteristics; several types of batik

from West Java, such as Banyumasan Batik, Ciamis Batik, Indramayu Batik, and Cirebon Batik. Batik from Central Java such as Batik Solo, Batik Bayat, Batik Lasem, and others. In addition, there are Tuban Batik, Madura Batik, Lamongan Batik, and many more from East Java. Each batik has characteristics that are seen from the level of subtlety of different motifs (Setiawan et al., 2018).

A known characteristic of Batik Sendang is that the motifs are very small and complicated, so as a craftsman, Batik Sendang must have a very high level of patience. The informant also said that the types of motifs from Batik Sendang, such as Kedawung, Kawung, Namkatil, Grinsing, Gendagan, Utah Rice, Crow Siup, Parang, and many more. Meanwhile, according to the Sendang Batik craftsmen, the typical or iconic features of the Sendang Duwur and Lamongan areas are usually added with the motifs of Milkfish Lele, Singo Mengkok, and Gapura.

The process of making batik conveyed by informants in interviews is generally the same as in other areas, as quoted in Agustin (2018). According to the research by Mulyani (2020), to make Sukapura batik, there are several stages, starting from the cloth being rolled, buried, walled, popped, and colored. While making Batik Sendang there are unique terms, for a complete explanation of the process of making Batik Sendang can be seen in Table 2.

Table 2 Explanation of the process of making hand-drawn batik

Stage	Explanation
<i>Nyungging</i>	Making drawing patterns on paper
<i>Njiplak</i>	Transferring patterns from paper to fabric by tracing or copying
<i>Nglowong</i>	The stage of attaching the wax (candle) to cover the lines of the previously made pattern
<i>Ngiseni</i>	The stage of giving ornaments or motifs to batiks, such as plants, animals, or other motifs
<i>Nyolet</i>	Coloring process with a brush
<i>Mopok</i>	Cover with wax (wax) the previously colored part (nyolet)

Stage	Explanation
<i>Nembok</i>	The process of closing with malam on the part of the background that is not colored
<i>Ngelir</i>	Full dyeing of the fabric by immersing it using a dye solution, both natural dyes and chemical dyes
<i>Nglorod</i>	The process of dissolving the wax by soaking the cloth in boiling water
<i>Ngrentesi</i>	Dot the blank pattern with the wax using a thin needle canting
<i>Nyumri</i>	Closing of certain sections with wax
<i>Nglorod</i>	The last step is to dissolve the wax on the cloth by putting it in boiling water

Research conducted by Zayyadi (2017) results in each depiction of batik patterns showing straight lines, curved lines, parallel lines, symmetry, points, angles, rectangles, triangles, and other similar concepts. As in Mulyani's research (2020) which explores mathematical activities in the batik process, the author also presents the activity of applying Physics concepts, especially on the temperature and heat material in the Sendang Batik-making process.

Based on curriculum 2013 analysis and material analysis, this concept can be explored in learning physics to achieve KD 3.5 and 3.6. The basic competencies explain the temperature and heat in life, everyday life, and technology.

On the other hand, in *Merdeka's* curriculum, this material is suitable for integration with learning objectives 11.11 Students can analyze the state of matter, its characteristics, and its behavior when receiving or releasing heat. on these learning objectives can be broken down into more complex learning outcomes.

Drawing Batik Patterns

Drawing batik patterns is easier in a place with sufficient lighting, both sunlight and light. When a person is in the sun or under a lamp, that person will feel hotter and hotter over time. It happens because of a temperature change. Figure 2 shows the process of drawing batik patterns.



Figure 2 Drawing batik patterns

Sendang Batik motifs have characteristics that make them different from other batik motifs. In batik activities, lights are added so that artisans can optimally draw the desired pattern of batik motifs. In physics, using additional lighting with lamps will generate light and heat energy due to rising temperatures.

Before the batik craftsmen start to draw patterns, there is a process called "*diketel*". In this process, it is intended that the fibers of the cloth expand so that it is easier to draw, and when dyeing, the cloth will absorb color more quickly. This process is an example of applying the expansion concept due to a temperature change. Figure 3 shows the expansion due to a temperature change in batik clothes.

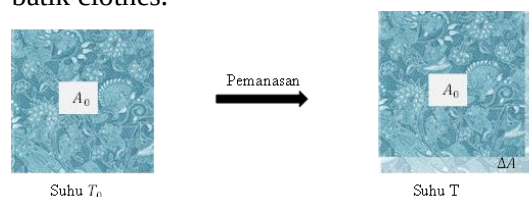


Figure 3 Expansion due to a temperature change

Batik Process

During the batik process, artisans heat the wax on the stove to melt it. Physically, this process occurs because the stove conducts heat to the pan so that the pan becomes hot. The heat in the pan is then sent back to the wax so that the wax can melt. This event shows that heat can transfer from one object to another. Figure 4 shows a traditional stove that use to melt batik wax. We will discuss a complete explanation of the heated material.



Figure 4 Stove that use to melt batik wax

Coloring Batik Cloth

The stage of coloring batik cloth can be done in two ways, and the first is coloring batik cloth using a brush. This technique can be called the dab technique. *Nyolet* is used to dye cloth in certain parts.

The second technique of coloring batik cloth is by soaking the batik cloth thoroughly in cloth dye. This second technique is done to give the basic color of the batik cloth when it is finished. After the dyeing process, the dyed fabric will be better and last longer if the fixation process is carried out. The fixation process is intended so that the resulting color does not fade easily. There are many types of dyes for batik cloth, ranging from natural dyes from plants to chemicals such as Neptol, Remasol, and Indigosol.

Boiling and Drying Batik Fabrics

Boiling batik cloth, also known as the *nglorod* process, is a process carried out to remove wax that was previously attached to batik cloth. In this process, the cloth is boiled in boiling water so the

wax melts again. As shown in Figure 5, batik artisans use wood to move the batik cloth from the pot so it doesn't feel hot.



Figure 5 Boiling Batik Cloth

Even so, the craftsman will still feel the heat from the stove even if he doesn't touch it directly. It can happen because heat can transfer in three ways. Likewise, batik cloth can be dried in direct sunlight or aired during drying. Here are three methods of heat transfer.

Conduction

Conduction is transferring heat from one object to another through a medium. During heat transfer, neither the substance nor the atoms of its constituent molecules move. Heat transfer by conduction due to the movement of electrons only occurs in metallic materials (materials containing free electrons). Figure 6 shows the conduction process illustration.

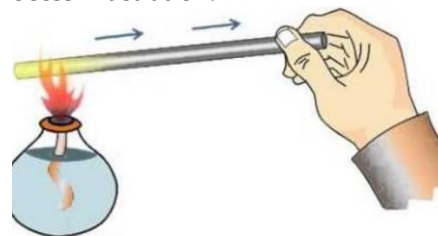


Figure 6 Conduction Process
(resource: <https://rpp.co.id/wp-content/uploads/2022/05/pengertian-konduksi-696x348.jpg>)

This process occurs at the *Nglowong*, *Mopok*, *Nglorod*, *Ngrentesi*, and *Nyumri* stages of batik. The heat transfer occurs in the pan used to melt the wax (wax), canting, and the pan used to boil water. Figure 7 shows the process of making batik that uses conduction theory.

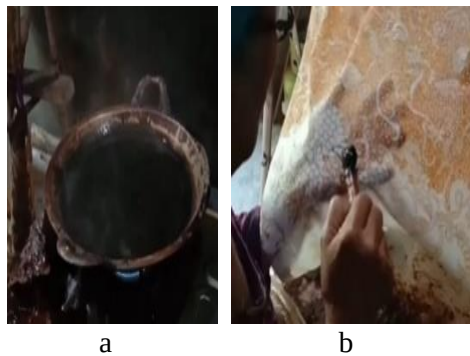


Figure 7 a. The process of melting wax with the wok media used for *nglowong, mopok*. b. The process of putting wax on the cloth using *canting* media

Heat transfer by conduction due to atomic vibrations can occur in all solids. However, heat transfer by conduction due to the movement of electrons is much easier than by atomic vibrational conduction. Therefore, conduction events in metals are much easier than those in non-metallic materials. In an insulator, conduction also occurs (because of the oscillations of moving atoms) but so slowly that the material is said to be a barrier to heat flow. If one end of the glass is heated, the other will heat up after a long time. This is evidence for conduction events in non-metals. Examples of insulating materials are wood, plastic, and rubber. The handle of the *canting* as a medium for incising wax on the cloth is made of wood with the aim that the craftsmen's hands do not feel hot when making batik. Figure 8 shows *Canting*, the tool for making batik patterns.



Figure 8 *Canting*, insulating *canting* handle

Convection

Convection is the transfer of heat propagated by the motion of the molecules of an object. When a part of an object receives heat, its constituent atoms move faster. As a result, the atoms are pushed (moved) to where the atoms are still slowly oscillating. Fast-moving atomic transitions carry heat energy. Therefore, heat moves from areas of high temperature to areas of low temperature. The illustration is shown in Figure 9.

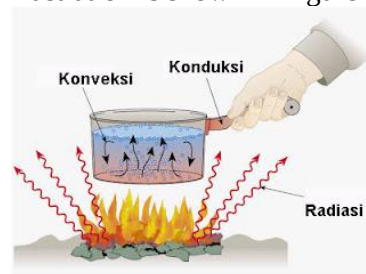


Figure 9 Convection, conduction, and radiation process

(resource:

<https://lifestyle.kontan.co.id/news/perpin-dahan-kalor-macam-macam-jenis-pengertian-dan-contohnya>)

The heat transfer process by convection occurs at the stages of batik *Nglowong, Mopok, Nglorod, Ngrentesi, Nyumri*. The heat transfer process occurs at malam (candle) which is heated to melt, water is heated to boil. In figure 10 are show the process of melting wax.



Figure 10 The process of melting wax (wax) and boiling water in the batik process

Convection only occurs in objects whose molecules can move freely. An object like this is a liquid consisting of a liquid and a gas. Therefore, convection occurs in liquids or gases. When the water in the pot is heated, the part that receives heat is the part in contact with

the pan, namely the bottom. However, over time all parts of the water become hot because of the flow of water molecules from the bottom up. The current pushes the cold water up and down to warm it.

Radiation

Radiation is the transfer of heat without passing through a medium. An example of radiation heat transfer is the space between the sun and the earth is a vacuum, but even so, we can still feel the sun's heat. Air is a poor conductor of heat. When we light a bonfire, we who are sitting about half a meter from the bonfire feel the heat. The last process of making batik is shown in Figure 11.

Radiation events occur at the batik stage, namely at the stage of drying the cloth. The process of heating cloth with sunlight occurs without a medium as an intermediary; besides that, we can feel the radiation process when we are near a fire at other stages, such as during the *Nglorod*, *Nglowong*, and other processes that make us near the fire so that our bodies feel the heat even though we do not touch the heat source.



Figure 11 The process of drying batik cloth in the sun

Previous research on batik local wisdom integrated into science includes the effectiveness of using tools and materials (Subekti et al., 2020), meaning and philosophy of motive (Trixie, 2020), waste treatment (Muljadi, 2013), ethnoscience learning (Irawan et al.,

2019; Shabrina & Kuswanto, 2018; Yun, 2020). However, batik ethnoscience research on physics is still rarely done. This study's discussion of the concept of physics is still limited to temperature and heat. For this reason, further research is expected to be able to examine the process of making batik in physics concepts more deeply. In addition, batik patterns can also be studied using chaos theory or what is known as chaos theory.

CONCLUSION

There is a physical concept that is applied in the activity of making Batik Sendang Duwur. From the research that has been done, there are several stages in the process of making Batik Sendang that apply the concept of physics, especially to the heat transfer material. Heat transfer can be done in three ways: conduction, convection, and radiation. Heat transfer by conduction occurs when heat transfers with a medium or an intermediary, but the medium molecules do not experience displacement. This process occurs in the *Nglowong*, *Mopok*, *Nglorod*, *Ngrentesi*, and *Nyumri* batik processes. The heat transfer occurs in the pan used to melt the wax (wax), canting, and the pan used to boil water. The convection occurs due to the movement of the object molecules that receive heat so that they move faster; this occurs at the batik stage of *Nglowong*, *Mopok*, *Nglorod*, *Ngrentesi*, *Nyumri*. The heat transfer process occurs at malam (candle) which is heated to melt, water is heated to boil. While the radiation process occurs at the batik stage, namely at the stage of drying the cloth. The process of heating the fabric with sunlight occurs without a medium as an intermediary.

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