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STEAM PROJECT-BASED LEARNING DEVELOPMENT: THE APPLICATION OF PHYSICS OF COLOR ON TIE-DYED TEXTILE

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Abstrak

Perpaduan dan pencampuran warna pada motif tekstil hasil pencelupan teknik tie dye memiliki harmoni unsure physic panjang gelombang warna (ºA). Melalui proses belajar Project Base Learning (PBL) secara berkelompok mahasiswa dapat mengembangkan ide kreatif dan inovatif dalam menghasilkan product karya tie dye dan di analisis berdasarkan science technology education art and match (STEAM). Penelitian deskriptif kualitatif ini menghasilkan produk tekstil tie dye yang beragam dengan pencampuran warna menghasilkan warna-warna dengan panjang gelombang warna bervariasi hasil dari pencampuran warna dasar dan warna sekunder, yang menghasilkan warna tertier dan warna empat dimensi yang indah pada desain permukaan motif tekstil.

Kata-kata kunci: fisika warna, panjang gelombang warna, tekstil tie dye, STEAM.

Abstract

The combination of colors on motif textiles using tie-dye techniques has a wide range of the color spectrum (ºA). This study analyzed the tie-dyed textiles produced by undergraduate students after participating in STEAM project-based learning activities in a group. This descriptive qualitative study concluded that the tie-dyed textiles had a varying color spectrum due to combining primary and secondary colors, which produced beautiful four-dimensional colors on the surface of motif textiles.

Keywords: physics of color, color spectrum, tie-dyed textiles, STEAM.

PENDAHULUAN

Most educational practices are familiar with STEM (Science, Technology, Engineering, and Mathematics). STEM first appeared in the United States in the early 2000s [1]. While STEAM (Science, Technology, Engineering, Arts, and Mathematics) emerged after research conducted by Georgette Yakman in 2006 [2]. The main difference between STEM and STEAM is that STEAM focuses on the arts, whereas STEM does not. In addition, STEM can be developed by linking materials and local wisdom [3].

Basically, in the STEAM learning and teaching process, information is shaped through collaborative risk-taking and creativity. Students will use skills in science, technology, engineering, arts, and mathematics in the learning process [4]. Placing art and design in this educational model will encourage students to be more creative and innovative, so it is hoped that graduates who use this learning model will have various skills that can support them in finding work in the future. one of them is by learning about color in physics with the concepts in tie-dyed textile.

Textile dyeing requires basic knowledge of color theory, namely the color spectrum, which combines primary, secondary, and tertiary colors to produce motifs with high artistic values. Tie-dye products in textiles generally use red, green, blue, yellow, and a mixture of the four, which can make purple (380-450nm), blue (450-495nm), green (495-570nm), yellow (570-590nm), orange (590-620nm), and red (620-750nm). Sadjiman Ebdi Sanyoto (2005:9) defines color physically and psychologically [5]. Physically, color is the light when emitted, while psychologically, color is part of human sight experience. There are three elements of color: objects, visuals, and light. In general, color can be defined as the element of light reflected by an object.

In general, tie-dye motifs use a combination of red, green, blue, and yellow. These colors are psychologically appealing to the eyes. According to Francois d'Aguilons' (1613) theory of mixing colors, white and black are the primary colors, while red, yellow, and blue are high positions. In his book Optics (1704), Newton argues that color is light. Light is the source of any object's color [6].

The wavelength of the visible light spectrum is about 380 to 700nm, the frequency of the light spectrum is about 430-770 THz. The visible spectrum is the part of the electromagnetic spectrum that the human eye can see. Colors that contain only one wavelength are called spectral colors. Ni Luh Putu Mustia Sridewi states that the red color has a large wavelength, resulting in a greater output power than yellow, green, and blue [7]. This study describes the tie-dyed textiles produced by Apparel Design undergraduate students after participating in project-based learning activities in a group. The participating students were made into groups and were instructed to make textile products with tie-dye techniques. The student experiment began with handing in their experiment proposal containing coloring, tying, and dyeing plans. The result of their experiments was then analyzed using STEAM. The assessment also covered the students' creativity and ability to apply color theory.

The implementation of this project-based learning was intended to make students understand that the tie-dyed textile products involve the application of color spectrum theory as well as the idea of tie-dying, education, art, and math [8, 9].

METODOLOGI

This qualitative descriptive study describes five textile products produced by 20 undergraduate students of Apparel Design Study Program in Universitas Negeri Jakarta after they participated in a project-based learning in a group of four which was conducted in a blended learning environment (Zoom, web, experiment, discussion in Whatsapp group, and group presentation) for five meetings. The following table describes the learning process.

TABLE 1. Tie-Dye Learning Process

Meeting	Learning Process	Media
1 (3-3-21)	Learning input (presentation by lecturer)	Zoom – PowerPoint
2 (10-3-21)	Experiment proposal submitted by students	By Email – Whatsapp Group
3 (17-3-21)	Experiment	WFH
4 (24-3-21)	Discussion on experiment result	By Whatsapp Group
5 (31-3-21)	Group presentation	Zoom – ppt

Lesson Presentation

Science

According to Sir Isaac Newton's (1680) color theory, all colors are combined as white light, a measurable bond of atomic rays. This theory connects the color theory of red, orange, yellow, green, blue, indigo, purple, which became known as the color circle. J.C Le Blon (1973) discovered the primary colors, namely red, yellow, and blue, which came from pigments (colors from powder) and applied these colors to works of art. Meanwhile, the person who first mixed the primary colors to create secondary colors was Mozes Harris.

Johan Wolfgang von Goethe (1810) developed three secondary colors from yellow (bright) and blue (dark). Michel Eugene Chevreul (1824), in the laws of simultaneous contrast of color (1939), explains that the more colors in a composition, the harder it is to determine the focal point.

Furthermore, the red-yellow-blue color is known as Brewster's theory. This name is taken from the name of a Scottish physicist.

The color was arranged by Munsell (1912) into a dimension I color name, dimension II degrees of color, and dimension III intensity. Primary Colors: red, yellow, blue. Secondary colors: orange, purple, green. Tertiary colors are a mixture of primary and secondary colors.

FIGURE 1. Color Wheel by Munsell 1912

Color can be defined objectively/physically as emitted light and subjectively/psychologically as part of human sight experience [10]. Color becomes visible because of the light that hits the object, and the thing reflects the morning to the eye (retina), which is then translated by the brain. Colors can be classified into five groups, namely:

- Primary Colors are basic colors that do not come from a mixture of other colors. The colors included in the primary color group are red, blue, and yellow.
- Secondary colors result from mixing primary colors in a 1:1 ratio. The colors included in the secondary color group are orange, purple, and green.
- Intermediate colors are between the primary and secondary colors on the color wheel. The colors included in the intermediate color group are yellow-green, yellow-orange, red-orange, red-purple, blue-purple, and blue-green.
- Tertiary colors are colors that are the result of mixing secondary colors. The colors included in the tertiary color group are yellow-brown, red-brown, and blue-brown.
- Quaternary colors are the result of mixing two tertiary colors. The colors included in the quaternary color group are orange-brown, green-brown, and purple-brown.

According to Nugroho (2008: 35-36), color is believed to have a psychological impact on humans. The following is a color classification based on psychological implications, namely:

FIGURE 2. Color Classification Image Based on Psychological Impact [11].

- Neutral colors are colors that no longer have color purity. This color is a mixture of three-color components at once, but not in the same composition. Examples of neutral colors are black, white, brown, gray, gold and silver.

- Contrasting colors are colors that appear opposite to each other. Students can obtain contrasting colors from opposite colors, consisting of primary colors and secondary colors. Examples of contrasting colors are red with green, yellow with purple, and blue with orange.
- Warm colors are color groups in the semi-circle within the color circle from red to yellow. In general, this color symbolizes cheerfulness, enthusiasm, anger, etc.

Tie-Dye Techniques (Technology)

Textile products are produced using dyeing techniques with temperatures between 60^{0}C - 80^{0}C. This temperature range was chosen because of the type of textile material used. Namely, cotton will degrade if it is above 100^{0}C. Meanwhile, the dyeing process takes between 40-60 minutes for the color to be absorbed into the cotton through diffusion, migration, absorption, and fixation processes.

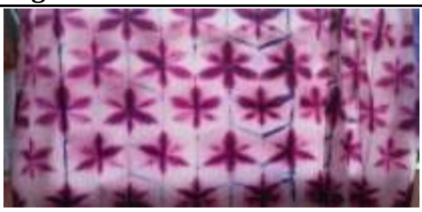
Art & Math

The resulting textile products also involve the art of tying and folding fabrics by applying symmetrical, geometric, triangular, circular, rectangular, and parallelogram shapes, which will then give repeated motifs and form repetitions of the same motif.

HASIL DAN PEMBAHASAN

The textile products made by the students were presented in the following table:

TABLE 2. Tie-Dyed Textile Products Produced by Students after Participating in the STEAM Project-Based Learning

Number	Figure	Number	Figure
Group 1		Group 4	
Group 2		Group 5	
Group 3			

The results of STEAM analysis on the tie-dyed textile products is presented in the following:

The textile fabrics used were cotton, and the dyeing process used natural coloring and used primary colors, including blue (450-495nm), green (495-570nm), yellow (570-590nm), red (620-750nm), which produces secondary colors, and has wavelengths of color between the secondary colors. In group 1, a reddish-purple (magenta) was created by mixing red and blue, where the composition of red is more dominant than blue, so the absorbed color was red. In contrast, blue was formed on the sides to create a triangular symmetrical network. The triangular tying technique on the fabric produced a three-dimensional motif. The tying triangular-shaped materials made symmetrical motifs with the same repeating motifs and colors. The dying process was carried out at 80oC for 45 minutes. This duration is considered optimal for the fabric to absorb the dye.

FIGURE 3. Triangle geometric folding technique and dying technique

The textile product of group 2 used a circular motif with centrifugal style. The colors used were red, yellow, green, and blue, which were scattered but did not produce secondary colors in the tie-dye coloring process because the coloring technique used was a spray technique using a spray bottle. The coloring technique used a solution temperature of 40^{o}C with a ratio of dye and water 1: 1. Color fixation occurred during the drying process.

The textile product of group 3 used circular mathematical motifs with rounded ties scattered on the fabric's surface. The colors are dominated by red, blue, green, and yellow and produce secondary colors pink and orange. These colors were produced by the absorption of colors from red and yellow. Group 3 used the dyeing technique at a temperature of 60^{o}C for 40 minutes so that the tertiary color would appear in the tie-dye dyeing process.

The exact process was also carried out to produce the textile product of group 4. The dying process took 40 minutes at a temperature of 60^{o}C. The colors produced by this process are sharp, and secondary and tertiary colors of pink and orange are also formed. In group 4, the tying techniques used were parallelogram symmetrical.

Meanwhile, the textile product of group 5 produced a brown color resulting from a mixture of blue-red and green-yellow. The irregular round tie technique forms a scattered round motif dominated by red and blue colors. New colors appear because of the mixing of primary and secondary colors, which produce tertiary colors. In addition, the dyeing temperature, dyeing technique, and dyeing process time will have different color wavelengths.

In physics, study the wavelength of each color into the material light waves. Light waves can be studied using serious games and improve student learning outcomes [12]. In addition, in modern physics, students will also explore the photoelectric effect [13]. The photoelectric effect occurs when one of the metal plates is exposed to light (photons), in which the light's ability to move electrons depends on the frequency (related to color). Therefore, by involving STEAM, it is hoped that students will become more interested in studying physics.

SIMPULAN

After being developed with Science, Technology, Education, Art, and Math, the tie-dye project-based learning, which involved physics color spectrum theory, produced textile products with high artistic and creative values. The tie-dye textile motifs were produced by mixing primary and secondary colors, producing tertiary colors with binding techniques and folding techniques to form symmetrical geometry, which gives a four-dimensional motif resulting from a combination of color mixing and symmetrical geometric shapes.

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