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The Framework RBL-STEM Learning Activity: Designing Batik Motifs as Local Wisdom Based Crafts Business on a Marketplace in Fostering Students' Digital Marketing Literacy

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Abstract
Digital marketing literacy is an understanding and capability of an individual to recognize, use, and leverage various strategies and tools of digital marketing to achieve business goals and build an effective online presence. This encompasses comprehension of various digital platforms such as social media, websites, search engines, emails, and others, along with the ability to analyze data and measure the performance of digital campaigns. However, students' digital marketing literacy skills are still relatively low. One of the reasons for this low proficiency is the learning models implemented so far that has not been able to develop these skills adequately. Therefore, in this study, a Research-Based Learning (RBL) model integrated with the STEM approach will be applied to design batik motifs with local wisdom as a marketplace-based craft business. This type of research employs a qualitative methodology. In this research, syntax for the development of learning activities using Research-Based Learning (RBL) and STEM approach will be formulated, incorporating assessment indicators for digital marketing literacy skills. The results show that there are six stage of learning activities as a framework for developming RBL-STEM learning materials.

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Keywords: Batik Design, Digital Marketing Literacy, and RBL-STEM

Introduction

Research-based learning is an instructional approach that emphasizes direct experience, exploration, and experimentation in understanding concepts and solving problems. This approach encourages learners to actively engage in knowledge acquisition through inquiry and discovery processes. In research-based learning, students assume the role of researchers seeking answers and solutions to given questions or tasks. Essentially, research based learning encourages students to learn in a deeper and more meaningful way by involving them in exploring topics or issues that are interesting and relevant to them. The research process helps students develop critical skills such as data analysis, evidence-based decision-making, and the ability to present their findings clearly and logically.

In the context of education, research-based learning also prepares students to become critical and innovative thinkers as they learn to formulate appropriate questions, seek reliable sources of information, and build arguments based on their findings (Hakim *et al*., 2021) [3]. Beyond rote memorization, students are equipped to be independent and resourceful researchers in facing real-world challenges.

Dafik (2018) [15] outlines seven stages of research-based learning: (1) problem posing, where open-ended problems are identified within the research group, (2) learners are encouraged to develop problem-solving strategies, (3) data collection involving orientation, tabulation, and hypothesis formulation, (4) data analysis, prediction processes, and validation, (5) formulation of conjectures, corollaries, hypotheses/lemmas, theorems, and generalizations, (6) group discussions within the research group, and (7) RBL reporting. RBL can be combined with the STEM approach, as done in the studies by Humaizah *et al*. (2020), Mursyidah *et al*. (2023) [6], Izza *et al*. (2023) [12], Dini *et al*. (2023), and Kristiana *et al*. (2022) [7]. STEM stands for "Science, Technology, Engineering, and Mathematics." The STEM concept refers to an educational approach that integrates these four fields to teach scientific concepts and technical skills to students holistically. The goal is to prepare students with a deep understanding of science and technology, along with the skills needed to tackle real-world challenges. The syntax used in RBL STEM is as follows: (1) Science (problem posing on several problems), (2) Engineering (Develop a solution to real-world problems), (3) Technology (Collecting data while tracing sources related to the things needed for the problem-solving process and understanding them), (4) Mathematics-Engineering (Build the theorem regarding the topics), (5) Mathematics (Proving the accuracy of the solutions), (6) RBL Report (Presenting the results of student research related to real-world problems).

Batik is a traditional art form that has existed for centuries and is an integral part of Indonesian culture (Marwan, 2022). Batik portrays its beauty and uniqueness through intricate patterns and motifs. One type of motif in batik is the line motif. The design of the line motif batik showcases patterns composed of connected, parallel, or winding lines. This motif can be used independently or as part of larger designs. The lines in the design often symbolize elements of nature, such as water, wind, earth, or flowers. In this study, we use batik with local wisdom from the Riau region (Yatim, 2018). The distinctive feature of Riau batik is its adoption of motifs inspired by local nature and culture, including flowers, leaves, binaang patterns, and intricate geometric designs. The dominant colors are natural hues. Batik motifs often convey moral messages, cultural values, or legendary stories passed down from generation to generation (Syahputri, 2021).

Fig 1: Batik Motif of Riau Islands

Graph Theory involves the study of relationships and patterns that occur in connected objects, such as vertices (points) and edges. In the design of line motif batik, interconnected lines can be seen as edges in a graph. Mathematics can be used to analyze the patterns of edge paths, the relationships between points connected by edges, and to study graph properties that arise in line motif batik designs (Izza *et al*., 2023) [12]. Mathematics also delves into patterns and sequences. Line motif batik designs often involve repeating consistent patterns. Mathematics can be employed to study these patterns, understand the sequences involved in creating batik designs, and even model these patterns using mathematical notations.

One concept in graph coloring is "local (a, d)-edge antimagic coloring." In this concept, the local (a, d)-edge antimagic coloring of G occurs if the set of edge colors forms an arithmetic sequence with an initial value a and difference d (Izza *et al*., 2023) [12]. The local (a, d)-edge antimagic chromatic number $X_{le}(a,d)\,(G)$ represents the minimum number of colors required to color G in such a way that a graph G admits the local (a, d)-edge antimagic coloring. The study of local (a, d)-edge antimagic coloring has intrigued researchers due to its unique properties and applications across various fields. Some frequently asked questions in this context include whether a specific graph has a local (a, d)-edge antimagic coloring and how to determine such coloring (Dafik *et al*., 2021) [2]. By applying mathematical concepts to the design of line motif batik, learning mathematics becomes more relevant and engaging for students. The application of mathematical concepts in a concrete context like batik design can help students understand mathematics in a more tangible and practical manner. Furthermore, learning mathematics can enrich students' understanding of Indonesian art and culture through their appreciation of line motif batik designs, which possess aesthetic value and relevant mathematical skills.

In the modern era, the development of information and communication technology has brought about profound changes in various aspects of life, including business and education (Nugraha, 2018). One significant change is the emergence of online platforms or marketplaces, enabling people to conduct businesses and interactions on a broader scale through the digital realm (Hitauruk *et al*., 2017). On the other hand, digital marketing literacy has become increasingly important in harnessing the vast potential of the digital market. Digital literacy has become a fundamental skill that everyone must possess to navigate the competitive modern world. In Indonesia, the level of digital literacy remains relatively low (Fharaz *et al*., 2022). Indicators and sub-indicators of digital marketing literacy skills can be observed in Table 1 (Rizal *et al*., 2022).

Table 1: Indicators and Description of Digital Marketing Literacy Skills

No.	Indicator	Description
1.	Transliteracy	Students can find information about batik that will be made (T1)
		Students can determine the target marketing consumers of batik that will be made (T2)
		Students can determine the marketing platform (T3)
2.	Managing Digital Identity	Students can determine the batik brand (MD1)
		Students can manage marketing platforms (MD2)
3.	Maintaining Privacy	Students can identify cyber security from the platform used (MP1)
		Students can apply cyber security (MP2)
4.	Creating Content	Students identify the concept of local (a,d)-edge antimagic coloring (C1)
		Students can find the graph to be used (C2)
		Students find point labeling in graphs (C3)
		Students calculate the edge weight of the graph according to the topic of of local (a,d)-edge antimagic coloring (C4)
		Students can design basic batik motifs according to of local (a,d)-edge antimagic coloring (C5)
		Students can add elements of local wisdom according to the region of origin (C6)
5.	Social Networking	Students can cooperate with batik producers through the designs that have been made (SN1)
		Students can upload batik results to the platform (SN2)
		Students disseminate products to social media (SN3)

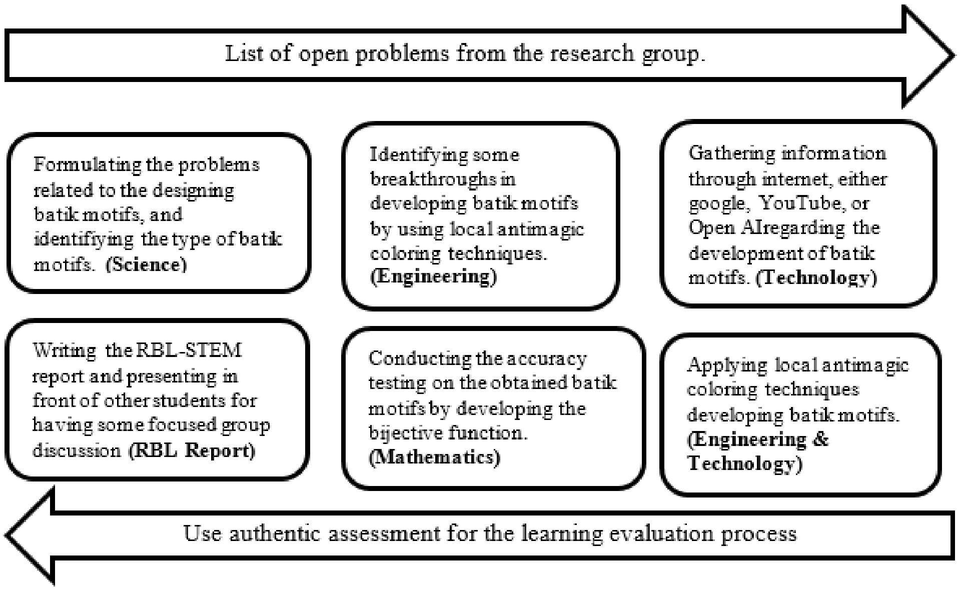


Fig 2: The Syntax of RBL-STEM in developing batik motifs using local antimagic coloring technique

Method

This type of research is a qualitative method. The research begins by collecting various literature to be reviewed regarding Research-Based Learning (RBL) and Science, Technology, Engineering, Arts, and Mathematics (STEAM). This also includes some exploration related to STEAM issues. Subsequently, we develop a learning activities framework for integrating RBL-STEAM in solving the STEAM problems followed by the development of indicators and sub-indicators related to digital marketing literacy. The research continues by implementing RBL-STEAM involving four elements together to address the makerspace problem on designing batik motifs as local wisdom based crafts business on a marketplace. Lastly, describe R&D plan using ADDIE model to develop RBL-STEM learning materials on designing batik motifs as local wisdom based crafts business on a marketplace, see the flowchart of the research procedur in Figure 5.

Research Findings

The Framework of RBL-STEM Syntax

In the following, we will present a framework for integrating the RBL learning model in the STEM approach to improve the students' digital marketing literacy in solving the disjoint union graph batik design problem by using the local (a,d)-edge antimagic coloring of the graph. The framework is developed based on the syntax proposed in (Arika *et al*., 2022). In the early stages of RBL syntax is posing problems arising from the research group's open problems. We consider the problem of disjoint union graph for line batik motif design as follows.

In this study, we consider the uniqueness of the pattern of the design of line batik motif design problem by using disjoint union graph and the accuracy of the number of line batik motif design required for special color and shape. Therefore the RBL-STEM model will undertake the following stages:

1. Fundamental problems related to the line batik motif design problem
2. Obtaining a breakthrough by using the local (a,d)-edge antimagic coloring of the graph
3. Data collection related to the data type being abused
4. Developing the design of line batik motif design by using the disjoint union graph and local (a, d)-edge antimagic coloring of the graph
5. Test the resulting line batik motif design
6. Reporting the research results and observations of

students' digital marketing literacy skills.

The framework for this RBL-STEM integration can be seen in detail in Figure. 2.

Students' Learning Outcome and Objective

Learning outcomes

Students can develop a disjoint union graph, especially line batik motif design by using the local (a,d)-edge antimagic coloring of the graph. Students can also test whether the obtained using local (a,d)-edge antimagic coloring of the graph can be tested generally by using an analytic and qualitative approach and obtain the several possible line batik motif design by using the disjoint union graph and local (a,d)-edge antimagic coloring of the graph.

Learning objectives

This RBL-STEM learning will enable students to develop knowledge and skills in the following fields of Science, Technology, Engineering, and Mathematics.

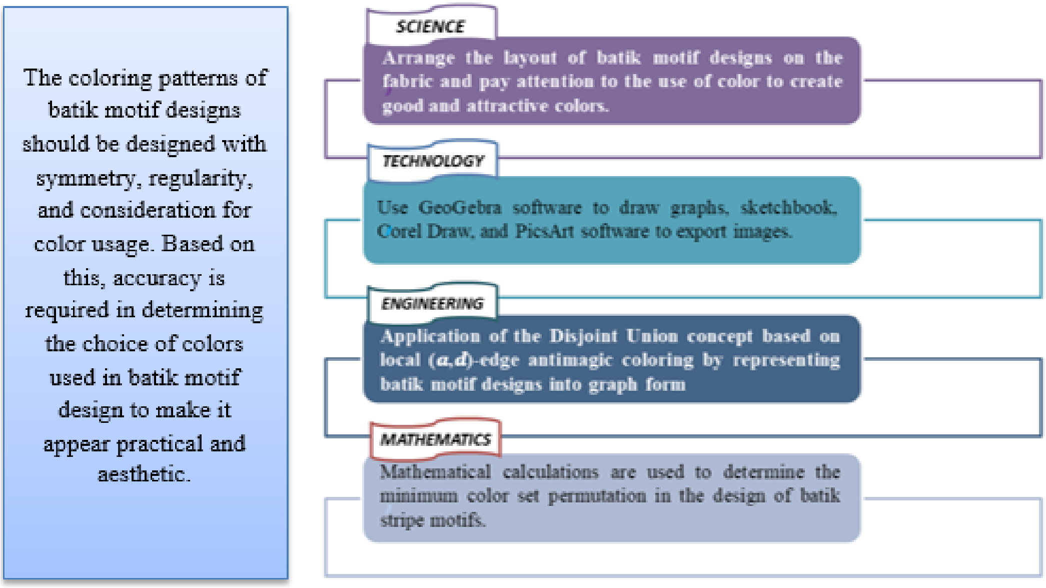


Fig 3: The STEM problem in developing the line batik motif design

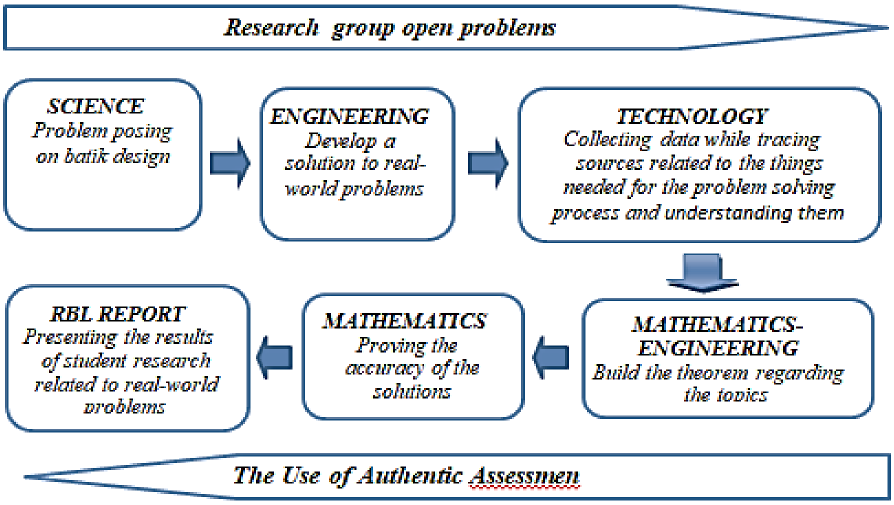


Fig 4: The framework of RBL-STEM in developing the line batik motif design

Sciences - Students are expected to:

- Understand the issues of line motif batik design,
- Analyze the arrangement and layout of batik motif designs on fabric, and pay attention to color usage, thus creating a good and appealing color composition.

Technology-students are expected to:

- Use a web browser to identify the concepts of local (a,d)-edge antimagic coloring and disjoint union,
- Utilize websites like Sciencedirect and others to find recent studies related to the concepts of local (a,d)-edge antimagic coloring and disjoint union,
- Harness software tools such as GeoGebra Classic, Fx Draw, and Corel Draw to draw graphs in line motif batik designs.

Engineering - Students are expected to:

- Developing local (a,d)-edge antimagic coloring techniques and disjoint union within the development of line motif batik design problems,
- Applying the concept of local (a,d)-edge antimagic coloring based on disjoint union from graph algorithms in developing line motif batik design problems.

Mathematics - Students are expected to:

- Develop the function of local (a,d)-edge antimagic coloring numbers based on the concept of disjoint union in the context of line motif batik design problems,
- Determining the fundamental batik design based on graph representation, and
- Determining coloration based on edge weights of the obtained graph.

On Line Batik Motif Design by Using Local (a, d)-edge Antimagic Coloring

1. The element of science problem

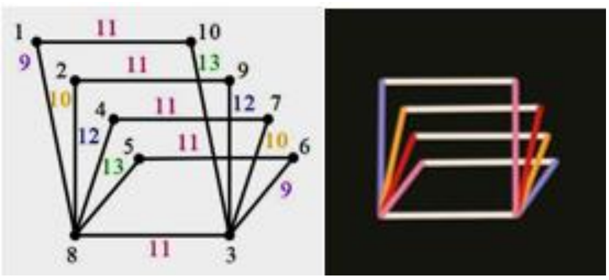
Batik is a craft that has high artistic value and has become part of Indonesian culture. The main element in batik is the motif, so that batik cannot be separated from the motif. Batik motifs consist of basic motifs or main motifs and additional motifs such as kiambang flowers (floating flowers), tobacco leaves, ferns and flowers. The batik used in this study uses the kiambang flower (floating flower) motif as an additional element in the batik motif design so that the batik contains elements of local wisdom, namely Riau. The types of colors used for batik range from textile dyes to natural dyes that come from nature or plants such as mangosteen peel, manganese leaves and turmeric, resulting in a variety of color variations.

2. The element of Mathematics

Testing the effectiveness of using local (a, d)-edge antimagic coloring based on disjoint union in batik design of line motif under mathematical analysis using analytical, qualitative and deductive techniques by developing algorithms in the form of mathematical functions. Batik is a craft with high artistic value and has become a part of Indonesian culture. The fundamental element in batik is the motif, making it inseparable from patterns. The coloring patterns and layout of batik design motifs must be symmetrically and systematically designed while considering the use of colors. Based on this, precision is required in determining the layout and the choice of colors used in designing batik motifs, in order to achieve a practical, aesthetic, and minimally colored result.

To create the arrangement of basic motifs, Corel Draw can be used along with employing the local (a,d)-edge antimagic coloring on the generated graph. This can help determine the variety of colors needed.

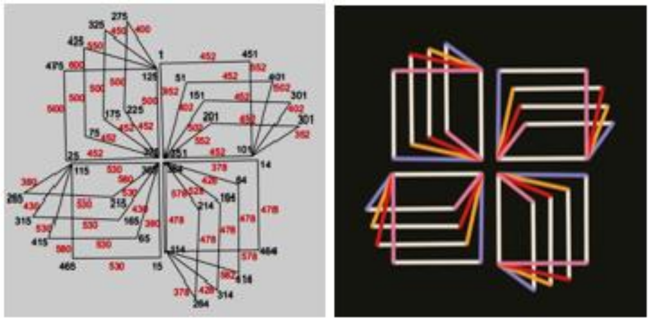
Stage 1: Creating graph labeling based on local (a,d)-edge antimagic coloring of graph B_4, for instance, utilizing a book graph as shown in Figure 4, then presenting the obtained graph in the form of batik motifs by employing coloring according to the obtained side labels. This process shapes a foundational batik motif.



a b

Fig 5: (a) Local (9, 2)-edge Antimagic Coloring of Graph B_4 (b) Basic Motif Representation

Stage 2: Creating graph labeling for disjoint union based on the local (352,2)-edge antimagic coloring of the graph ${}_{50}B_4$. This results in new point and edge weight labeling based on the disjoint union, where disjoint union represents any two disconnected graphs G and H. Let's assume the area to be colored represents a side; then, neighboring areas are connected by a point. By doing this, a consistent coloring pattern can be established for batik, ensuring that the same coloring exists between each book graph. Subsequently, presenting the disjoint union graph based on the local (352,2)-edge antimagic coloring of the ${}_{50}B_4$ in the form of batik motifs, resulting in the creation of a simple batik motif.



a b

Fig 6: (a) Disjoint Union Graph Based on the Local (352,2)-edge Antimagic Coloring of Graph ${}_{50}B_4$ (b) Representation in a Simple Motif

Stage 3: Creating the framework of a batik motif design using the lines of the disjoint union graph based on the local (352,2)-edge antimagic coloring of the graph ${}_{50}B_4$ on fabric, while simultaneously arranging an aesthetic, symmetric, and patterned layout.

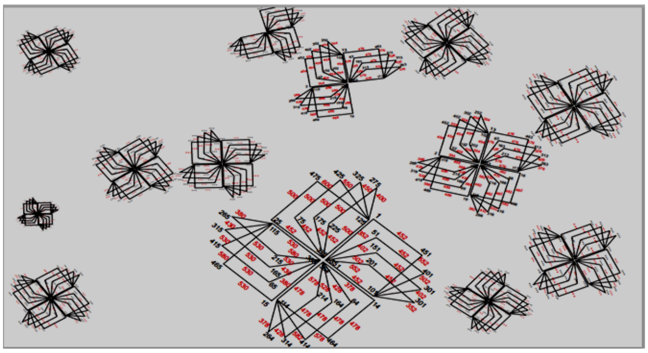


Fig 7: Framework of Disjoint Union Batik Motif Design Based on Local (352,2)-edge Antimagic Coloring of Graph ${}_{50}B_4$.

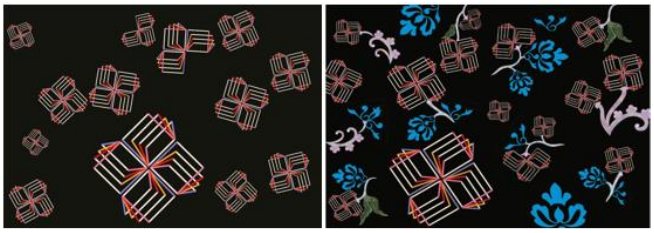
3. The element of engineering

The coloring patterns and layout of batik design must be designed symmetrically, systematically, and with attention to color usage. Based on this, precision is needed in determining the layout and the types of colors used in the batik design to make it appear practical, aesthetic, and achieve minimal coloring. To create the arrangement of the basic motif, Corel Draw can be used along with employing local (a,d)-edge antimagic coloring on the generated graph. This helps determine the variety of colors needed.

A special technique is required to design beautiful and patterned coloring. The technique used in this research is local (a,d)-edge antimagic coloring based on disjoint union. The idea of local (a,d)-edge antimagic coloring is to color the graph G such that the set of side colors forms an arithmetic sequence with an initial value of 'a' and a common difference of 'd'. Furthermore, the local (a,d)-edge antimagic chromatic number X_{le}(a,d) (G) is the minimum number of colors required to color G in such a way that G satisfies local (a,d)-edge antimagic coloring. Disjoint union, on the other hand, represents any two disconnected graphs G and H. There are several steps to determine the chromatic number in coloring the line motif batik design: 1) Label each side with labels equal to the number of sides in the graph. 2) Calculate the weight of each side in the graph. 3) Analyze whether the weight of each side in the graph forms an arithmetic sequence with an initial value of 'a' and a common difference of 'd'. 4) Label each side with labels equal to the number of sides in the disjoint union graph. 5) Calculate the weight of each side in the disjoint union graph. 6) Analyze whether the weight of each side in the graph forms an arithmetic sequence with an initial value of 'a' and a common difference of 'd'. 7) Color the basic batik motif according to the side weights in the obtained disjoint union graph.

Stage 4: Translating colors in the line motif batik design based on the side weights obtained from the disjoint union graph using the local (352,2)-edge antimagic coloring of the graph ${}_{50}B_4$. In this stage, selecting appropriate colors between different elements is necessary to make the main batik motif more appealing, aesthetic, and captivating, as shown in Figure 9(a).

Stage 5: Adding batik elements as accessories to the batik design based on the book graph. This addition includes elements like tobacco leaves and stems. To make the accessory composition more attractive, it should not dominate the main batik design, namely the book graph motif.



a b

Fig 8: (a) Framework of Graph Batik Motif Design. (b) Disjoint Union Batik Based on the Local (352,2)-edge Antimagic Coloring of Graph ${}_{50}B_4$ Representation in Line Batik Motif Design

Fig 9: Design of Traditional Riau Batik Motif Framework

In addition to the line motif designs from the book graph, there are also line motif designs derived from path graphs and star graphs. Presented here are several examples of line motif batik designs that have been developed following the graph structures and the established coloring patterns.

4. The use of the Internet of things

The technological elements involve the use of various types of software and online platforms to address the issue of coloring line motif batik designs. In this research, the software used includes GeoGebra Classic, Fx Draw, and Corel Draw for creating graphical illustrations in the line motif batik designs. The software GeoGebra Classic 6 is accessible online by visiting the following link: https://www.geogebra.org/classic?lang=id. by selecting the GeoGebra Classic mode, users can adjust the workspace by right-clicking and configuring axis and grid modes.

A b

Fig 10: (a) Designing Line Batik Motifs using Corel Draw, (b) Creating the Framework of Clothing with Line Batik Motif using Corel Draw

RBL-STEM Learning Activities on Line Batik Motif Design and Instruments Framework for Assessing Students' Digital Marketing Literacy

In this section, we will discuss each of the six stages of the research-based learning model with a STEM approach. These stages will illustrate how students engage in the learning process using the research-based learning model with a STEM approach, focusing on the utilization of the local (a,d)-edge antimagic coloring concept to enhance students' digital marketing literacy in solving line batik motif design problems. The first stage (Science) presents fundamental issues related to line batik motif design, where students are required to determine the layout and coloring of each motif to create a combination of colors that are both aesthetically pleasing and efficient.

Table 2: Learning Activity of RBL-STEM in Stage 1

Stage 1	Learning Activity
Presenting problems related to line batik motif design using the concept of local (a,d)-edge antimagic coloring based on disjoint union.	▪ The teacher asks the students if they have ever witnessed the process of creating batik motif designs.
	▪ The teacher presents an example of a line batik motif design to the students and then inquires whether the students are capable of developing their own arrangement of line batik motif designs..
	▪ Students engage in group discussions about developing the fundamental construction of line batik motif designs and attempt to analyze the colors of each motif.

The second stage involves techniques where students are asked to develop breakthroughs in solving given problems using coloring techniques, simultaneously enhancing students' digital marketing literacy skills. Previously, students were asked to identify types of simple graphs for colorings.

Table 3: Learning Activity of RBL-STEM in Stage 2

Stage 2	Learning Activity
Developing breakthroughs to solve line batik motif design problems using graph coloring techniques.	▪ The teacher guides students to discuss breakthroughs in solving line batik motif design problems.
	▪ The teacher explains the coloring process on simple graphs.
	▪ Students are asked to perform coloring on simple disjoint union graphs.

The third stage involves technology, where students are introduced to the use of GeoGebra software in solving line batik motif design problems.

Table 4: Learning Activities of RBL-STEM in Stage 3

Stage 3	Learning Activity
Gathering data and exploring relevant sources about the necessary aspects for the problem solving process and understanding them.	▪ Students are guided by the teacher to download and try using software to create graphs.
	▪ Collecting data related to local (a,d)-edge antimagic coloring by exploring scientific journals/ articles through ResearchGate or other online library channels.
	▪ Students can use encyclopedias (Google Scholar), ResearchGate, research profile sites (Scopus, Publons), cloud storage (SlideShare, LinkedIn, MOOCs), cloud meetings (Google Meet, Zoom, Cisco Webex) to find research about local (a,d)-edge antimagic coloring.
	▪ The teacher guides students to download and try using Corel Draw software.

The fourth stage is Mathematics-Technique, involving the development of theorems about the topic of local (a,d)-edge antimagic coloring on previously unexplored graphs.

Table 5. Learning Activities of RBL-STEM in Stage 4

Stage 4	Learning Activities
Students build theorems related to local (a,d)-edge antimagic coloring of a graph and identify each vertex and edge coloring.	• Students determine a graph and provide notations.
	• Students attempt to expand the graph.
	• Students determine the cardinality of vertices and edges.
	• Students generalize the cardinality used in the graph.
	• Students perform vertex and edge coloring according to the definition of local (a,d)-edge antimagic coloring.
	• Students determine the chromatic number.

The fifth stage is Mathematics, where students conduct testing on the acquired coloring to prove the accuracy of the solution.

Table 6: Learning Activities of RBL-STEM in Stage 5

Stage 5	Learning Activities
Students prove the accuracy of the local (a,d)-edge antimagic coloring theorem they have obtained.	• Students identify the set of vertices, set of edges, order, and size of the chosen graph.
	• Students prove the upper bound of the vertex coloring function and the edge coloring function.
	• Students prove the lower bound of the previously discovered theorem.
	• Students write down the proven theorem.

The sixth stage is the reporting phase, where students present their findings regarding the solution to the line batik motif design problem.

Table 7. Learning Activities of RBL-STEM in Stage 6

Stage 6	Learning Activities
Students present the research results related to the line batik motif design problem using the concept of local (a,d)-edge antimagic coloring based on disjoint union.	• Students develop a research report about the local (a,d)-edge antimagic coloring to determine the basic motifs of batik.
	• Students conduct presentations in front of the class for a focus group discussion.
	• The teacher evaluates and clarifies all the results of the students' research activities.
	• The teacher observes students' digital marketing literacy skills using observation sheets.

The Framework of Learning Material Process Development

The ADDIE development model consists of four stages that need to be carried out in the creation of instructional materials, namely the analyze stage, Design stage, Development stage, Implementation stage, and Evaluation stage. Here is an explanation of each stage:

First stage: analyze. This involves initial and final analysis, student analysis, conceptual material analysis, task analysis, and analysis of the intended learning objectives. Second stage: design. In this stage, instructional materials are designed, including the creation of Student Worksheets (LKS) and tests for digital marketing literacy skills. These materials use a research-based learning model with a STEM approach, focusing on the study of local (a,d)-edge antimagic coloring and utilizing digital marketing literacy skill indicators. Third stage: develop. At this stage, the instructional materials have been validated by experts to test the validity of the developed materials. The results of field trials and revisions from the experts are used as recommendations to produce the final materials, ready to be used in teaching. Fourth stage: implementation, is to evaluate the tool in the classroom and assess how well the RBL model of instruction combined with a STEM approach has improved students' digital marketing literacy when creating batik motif designs using any software and application design. The final stage is evaluation. The primary activities during this stage are evaluation and reflection of the implementation of the RBL model of teaching integrated with the STEM approach, which can enhance students' digital marketing literacy in batik design.

Discussion

Developing a framework for STEM-RBL learning activities in the development of line batik motif designs using local (a,d)-edge antimagic coloring to enhance students' digital marketing literacy skills is crucial, and serves as the starting point for the Research and Development format. This paper will serve as a guide for researchers to undertake further actions in research. There are at least two other research activities that can be pursued: (1) the development of STEM-RBL learning materials using the ADDIE development model, and (2) studying STEM-RBL learning materials to enhance students' digital marketing literacy skills in the development of line batik motif designs using local (a,d)-edge antimagic coloring. We consider learning activities that combine RBL-STEM to be highly effective in shaping students' digital marketing literacy skills, in line with the presented research outcomes (Alpian *et al*. 2023; Kristiana *et al*. 2022; Sumardi *et al*. 2022) [7]. Therefore, its implementation in the learning process is crucial. We predict that integrating RBL-STEM for other scientific and social issues will familiarize students with finding excellent breakthroughs in tackling complex problems. This is the key to nurturing a capable younger generation for the future a generation adept at creative innovation, critical thinking, collaboration, and communication.

Conclusion

We have developed the framework for STEM-RBL learning activities in the development of line batik motif designs using local (a,d)-edge antimagic coloring and disjoint union to enhance students' digital marketing literacy skills. We believe that this is essential to be done before proceeding to further research activities, namely Research and Development (R&D) and experimental research. However, this initial research is not without its challenges; therefore, collaborative research for other STEM cases needs to be explored, along with breakthroughs in solving STEM problems.

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