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Developing a Place-Based Science Teaching Kit Based on Batik Sendang Lamongan to Enhance Students' Critical Thinking and Environmental Literacy

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Abstract
This study aims to determine the feasibility and effectiveness of science learning devices incorporating the local potential of Batik Sendang Lamongan in improving students' critical thinking skills and environmental literacy. The study uses an R&D approach referring to the 4D model of Thiagarajan and Sanmel. Testing of the science learning device products was carried out in two stages: limited testing and empirical testing. The feasibility test of the developed science learning devices was conducted by two expert lecturers serving as validators. The practicality test was conducted by two science teachers. Limited testing was conducted on 15 students with varying academic abilities. The empirical trial was conducted in one experimental class consisting of 30 students and one control class consisting of 32 students. The data collection instruments used test techniques in the form of pretest and posttest sheets for critical thinking skills, and non-test techniques in the form of environmental literacy observation sheets. The research results showed that the experimental class demonstrated a moderate improvement in critical thinking skills (N-gain = 0.41) compared to the control class (N-gain = 0.05), and the experimental class showed a moderate improvement in environmental literacy (N-gain = 0.36) compared to the control class (N-gain = 0.24), than MANOVA results indicated a significant multivariate effect of the intervention ($p < 0.001$). These learning devices can be used in junior high schools/Islamic junior high schools (SMP/MTs) around Lamongan Regency and can be modified according to each region by paying attention to appropriate topics.

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INTRODUCTION

The rapid technological advancements of the 21st century have resulted in both positive and negative impacts and have transformed people's lives as they are facilitated by modern and practical tools. In addition, global competition in this era of globalization can also bring changes to people's lives. This, to some extent, can erode knowledge and love for the local wisdom possessed by a region. The preservation and safeguarding of local cultural heritage need to be carried out comprehensively and holistically. It is better to start by thinking locally for global purposes than to think globally while neglecting the local (Haryono, 2009). Each of the parties involved must have a joint commitment and balance, as well as align interests in the utilization of cultural heritage. The use of local cultural heritage should be oriented toward efforts to rescue and preserve it so that the negative impacts of its use can be prevented or at least minimized. In

addition, the process of educating the public to develop an appreciative attitude toward cultural heritage needs to be continuously carried out through various methods and media. Through an educational approach, it is hoped that attitudes and commitments can be formed to maintain and preserve local culture so that it can be utilized for national interests. Currently, we need to rethink our position in life, because we live between the past and the future (Nadjib, 2017). Local wisdom is able to endure, able to repel foreign cultures, has the ability to accommodate new incoming cultures, can integrate with new or foreign cultures, can control existing culture, and contributes values for the direction of future culture (Johan, 2011). Education infused with local wisdom can be carried out if teachers understand the insights of local wisdom itself. From there, learning that respects the diversity of regional cultures can be implemented. All components, whether formal education (school), informal education, or non-formal education, must make local wisdom values the basis for attitudes and behavior in community, national, and state life (Suyahman, 2017). Research on the utilization of local potential in science learning has developed rapidly in recent years, especially in the context of contextual learning that connects scientific concepts with students' real life experiences. Various studies have shown that local potential whether in the form of natural resources, culture, or local industries can be integrated into learning materials, modules, and learning activities such as project-based learning and field observations. This integration has been proven to enhance conceptual understanding, student engagement, and higher-order thinking skills, particularly critical thinking skills and environmental care attitudes (Nurjanah et al., 2023; Lestari & Rahmita, 2025). Other research also reinforces that science learning based on local potential can significantly improve students' critical thinking skills through authentic hands-on learning experiences (Anisa, 2017). In addition, the use of learning materials based on local potential is reported to have a positive effect on critical thinking abilities as well as students' environmental concern attitude as part of environmental literacy (Rahmi et al., 2022). However, most studies still focus on general local potentials, and on the other hand, there is still a research gap regarding the exploration of more specific and contextual local potentials, such as regional-specific batik, particularly Sendang Lamongan Batik, in science learning. Until now, there have not been many studies examining how the batik production process, which is rich in scientific concepts such as changes in substances, heat, and chemical changes, can be comprehensively integrated to improve students' critical thinking skills as well as environmental literacy. In fact, utilizing batik as a local potential has the advantage of a direct connection between science concepts and cultural practices and daily life, thus potentially creating learning that is more meaningful, contextual, and based on local wisdom. Furthermore, this integration can also strengthen environmental awareness through understanding the impact of batik waste and efforts to manage it. Thus, research on utilizing the local potential of Batik Sendang Lamongan in science learning has novelty in integrating cultural, scientific, and environmental aspects simultaneously, which not only enhances critical thinking skills but also strengthens students' environmental literacy holistically.

The utilization of local potential in science learning has a strong theoretical foundation within the framework of place-based education, contextual learning, and constructivist theory. Place-based education emphasizes that the local environment, both natural and cultural, is an authentic learning resource that allows students to learn through direct experiences relevant to their lives. In this context, local potential becomes a medium to present real problems that require processes of analysis, evaluation, and decision-making, which are at the core of critical thinking skills. In line with this, contextual learning (Contextual Teaching and Learning/CTL) emphasizes the connection between learning material and students' real-world situations, so that the concepts learned are not abstract but meaningful and applicable. Various studies show that a contextual approach can improve critical thinking skills because students are trained to connect concepts, analyze problems, and find solutions based on real experiences (Ziliwu & Mahmudi, 2025; Ratnaningsih et al., 2025; Patimah et al., 2025). The integration of local potential in this approach further strengthens the relevance of learning because students not only understand

science concepts but are also able to critique phenomena occurring in their surrounding environment (Auliya et al., 2025).

On the other hand, the constructivist learning theory provides an epistemological explanation that knowledge is actively constructed by students through interaction with the environment and learning experiences. From a constructivist perspective, local potential serves as a stimulus that enables the process of knowledge construction through observation, exploration, and reflection. These activities encourage students to ask questions, test hypotheses, and evaluate the results of their own thinking, which are key indicators of critical thinking. Research shows that the constructivist approach can enhance student learning activity and conceptual understanding through direct involvement in the learning process (Asrinawati et al., 2025). In addition, problem-based learning and contextual experiences have also been proven effective in developing aspects of critical thinking such as interpretation, analysis, and inference (Angelia et al., 2025). Thus, the integration of local potential in science learning is not only pedagogically relevant but also theoretically capable of optimizing the development of critical thinking skills through the synergy between contextual experiences, knowledge construction, and active student engagement in an authentic learning environment.

Based on the results of preliminary research conducted at SMP Negeri 5 Lamongan, the science learning tools used in the learning process still adhere to the learning tools created by the Lamongan District Science Teachers' Forum, taking into account the characteristics of each school, and no science learning tools containing local potential of the region have been found. Science learning is mostly limited to delivering existing theories and has not been connected to daily habits, making it less engaging for students. Therefore, it is important to study the Development of Science Learning Tools Containing the Local Potential of Batik Sendang Lamongan. It is necessary to research: 1) how feasible the developed science learning devices are; 2) how effective they are in improving critical thinking skills?; 3) how effective they are in improving environmental literacy.

METHODS

This research is a type of research and development (R&D) that adapts the 4D development model. The 4D development model consists of four stages: define, design, develop, and disseminate (Thiagarajan and Semmel, 1974). At the Define stage, a preliminary study is conducted to define the needs in the learning process, where at the define stage information is obtained regarding students' critical thinking skills and environmental literacy, concepts of science material that can be integrated with the local potential of Batik Sendang Lamongan, as well as to determine the learning objectives to be carried out. The Design stage is carried out to design the initial product based on the data obtained at the define stage. At this stage, the design of the format of the developed learning tools is carried out, media selection, and the preparation of research instruments. At this stage, a draft of the developed learning tools product and research instruments (test sheets, observation sheets, and validation sheets) is obtained. The Develop stage is carried out by conducting instrument validation by experts, limited trials, and field trials on the developed product. At this stage, a revised learning device product that is feasible for use is produced. The Disseminate stage is carried out by distributing the science learning device product containing the local potential of Batik Sendang Lamongan in schools and publishing it through scientific journals. The 4D development model is used because the stages are suitable for developing the product to be created in this study. The product to be created in this research is a science learning device incorporating the local potential of Batik Sendang Lamongan, including the syllabus, lesson plans, student worksheets (LKPD), and assessment sheets that will be applied in the topic of Classification of Matter and Its Changes.

The product testing in this study consisted of two stages, namely limited testing and field testing. The limited testing of the developed science learning device was carried out on 15 students with different academic abilities, namely 5 students with low ability, 5 students with

moderate ability, and 5 students with high ability. This limited testing was conducted by distributing the Student Worksheet (LKPD) to the students, having them complete the evaluation sheets, and asking them to provide feedback on the learning device that had been created. Field testing was conducted using two classes from grade VII, with the first class as the control class and the second class as the experimental class. The students who are the subjects of the study have diverse demographic characteristics, ranging in age from 12 to 14 years old, with a relatively balanced gender distribution between boys and girls, and come from low to upper-middle socioeconomic backgrounds identified through their parents' occupations and education levels.

The design used in the field trial was a pretest-posttest control group design. The trial design was used to determine the effect of using LKPD on students' critical thinking skills and environmental literacy in the control and experimental classes. The experimental design of the pretest-posttest control group design is shown in Table 1 below:

Table 1. Pretest-Posttest Control Group Experimental Design

Class	Pretest	Treatment	Posttest
Control (G1)	O1	X1	O2
Experiment (G2)	O3		O4

Description:
O1: initial ability of the control class
O2: final ability of the control class
O3: initial ability of the experimental class
O4: final ability of the experimental class
X1: learning using teaching materials from the teacher
X2: learning using teaching materials containing local potential of Batik Sendang Lamongan, development results

The trial of the science learning device containing the local potential of Batik Sendang Lamongan was conducted at SMPN 5 Lamongan for seventh-grade students by taking two trial classes. These two classes were used as control and experimental classes. The determination of the control and experimental classes was carried out using the cluster random sampling technique, which was done by randomly selecting samples on the condition that the classes were homogeneous. To determine the homogeneity, a homogeneity test was conducted on several existing seventh-grade classes.

The data collection techniques used in this study consisted of tests and non-tests. The tests used were essay questions, while the non-tests included interviews, observations, and questionnaires. Critical thinking skills are measured using a critical thinking skills test consisting of 10 essay questions that have been declared valid through an expert validation process. The indicators used to measure the critical thinking skills test are derived from a synthesis based on the opinions of several experts (e.g., Ennis; Facione; Peter; Fisher; and Kersting), resulting in critical thinking skill indicators including interpreting, analyzing, and concluding. Environmental literacy is measured using an environmental literacy observation sheet consisting of 12 items that have been declared valid through an expert validation process. The indicators used to measure environmental literacy are based on a synthesis of opinions from several experts (e.g., McBeth, Palmer & Philip, NAAEE, NCSU), resulting in environmental literacy indicators that include observing investigation objects, organizing investigation results, and planning problem-solving actions. The data analysis techniques carried out included: 1) the analysis of interview data was conducted descriptively and qualitatively; 2) the analysis of product validation assessment data was carried out by expert lecturers and practitioners based on the validation sheets that had been prepared, then coded on a qualitative scale from 1 to 4, after which the average for each aspect was calculated and converted based on the 4-point scale; 3) the analysis of the implementation of science learning incorporating the local potential of Batik Sendang Lamongan was obtained through observations conducted by two observers. The analysis of the feasibility of learning that incorporates the local potential of Batik Sendang Lamongan was conducted by converting 'Yes' answers into a score of 1 and 'No' answers into a score of 0. The total 'Yes' score was then

multiplied by 100%; 4) Data analysis to measure the effect of science learning tools incorporating the local potential of Batik Sendang Lamongan on improving students' critical thinking skills and environmental literacy was obtained through pretest and posttest results of students in the control and experimental classes. The pretest-posttest results for improving critical thinking skills can be determined using the gain score formula <g>, where the score gain categories are divided into three categories, namely $g \geq 0.7$ (high), $0.3 \leq g < 0.7$ (medium), and $g < 0.3$ (low); 5) Analysis of the effectiveness of science learning tools containing the local potential of Batik Sendang Lamongan in terms of critical thinking skills and environmental literacy through pretests and posttests. To analyze this, inferential statistical analysis is required, starting with prerequisite tests, namely the normality test using the Kolmogorov-Smirnov test and the homogeneity test using Levene's Test. Subsequently, a hypothesis test is conducted using the MANOVA test. The selection of Multivariate Analysis of Variance (MANOVA) in this study is based on the presence of two dependent variables measured simultaneously, namely critical thinking skills and environmental literacy, which are interconnected. MANOVA is used to determine the difference in the influence of learning devices between the experimental and control classes simultaneously, so that the analysis results are more comprehensive and can reduce the risk of Type I errors compared to testing separately.

RESULTS AND DISCUSSION

The product produced in this research is a science learning device containing the local potential of Batik Sendang Lamongan to improve students' critical thinking skills and environmental literacy. The material used is the Classification of Matter and Its Changes, which is integrated with the local potential of Batik Sendang Lamongan. The developed product is designed to enhance students' critical thinking skills and environmental literacy in the topic of Classification of Matter and Its Changes, which is composed of three subtopics: (1) characteristics of matter, elements, compounds, and mixtures; (2) separation of mixtures; and (3) physical changes and chemical changes. The steps used in this research refer to the 4D model consisting of four stages: define, design, develop, and disseminate. The results of the initial product development in this study are described in the define (definition) stage and the design (planning) stage.

The development of science learning tools in this study begins with the define stage, which consists of several steps: preliminary analysis, learner analysis, task analysis, concept analysis, and learning objectives analysis. Preliminary analysis is the initial step carried out by the researcher to obtain information about science learning tools, the curriculum, and school issues, especially concerning students' critical thinking skills and environmental literacy at the school. Additionally, it is also aimed at gathering information about the local potential of Batik Sendang Lamongan in relation to the integration of science learning. This preliminary analysis was conducted by interviewing the Science teacher at SMP Negeri 5 Lamongan and reviewing the science learning tools used by the teacher at the school, as well as interviewing craftsmen of Batik Sendang Lamongan. From this preliminary analysis, information was obtained that the science learning tools used are those developed in collaboration with the Lamongan Regency Science Teachers Forum, and there are no integrated science learning tools utilizing local potential in use. Furthermore, regarding the local potential of Batik Sendang Lamongan, information was obtained about the tools, materials, motifs, and the production process of Batik Sendang Lamongan. The abilities measured are still limited to cognitive skills, while critical thinking skills and environmental literacy are still rarely assessed. Based on the results of preliminary analysis that has been conducted, the researcher developed science learning materials containing the local potential of Batik Sendang Lamongan, which is close to the students' lives and their residential areas. The development of these science learning materials is expected to assist teachers in accompanying students during learning activities and is also expected to help students improve

their willingness to learn, thereby enhancing their critical thinking skills and environmental literacy.

Student analysis is conducted after the preliminary analysis is obtained. In this step, the researcher conducts a student analysis to understand the condition of the students. Student analysis is also carried out by the researcher to adjust the learning materials to the developmental level of the students who will be used as research samples. The results of the student analysis obtained in this study indicate that students at SMP Negeri 5 Lamongan are not very enthusiastic about science lessons, and students pay little attention when the teacher delivers the lesson. This situation results in students' critical thinking skills and environmental literacy still being low. This is caused by many factors, including the learning environment, especially the background in the family environment, students' learning motivation, and the lack of learning contextual resources related to the students' environmental conditions. Based on the analysis of students that has been conducted, the researcher developed a science learning device integrated with the local potential of Batik Sendang Lamongan, which is expected to help students in their learning.

The task analysis in this study was conducted to determine the tasks that will be presented in the learning devices based on the applicable curriculum. The development of the learning devices in this study refers to the core competencies and basic competencies that are appropriate for the level of the educational unit. The tasks in the learning devices are arranged by integrating the local potential of Batik Sendang Lamongan. The task analysis examines the overall topics that will be presented in the learning tools, particularly as outlined in the Student Worksheet, to be used by teachers in guiding students during learning activities. The material compiled in the learning tools is designed to achieve the core competencies and basic competencies related to the Classification of Matter and Its Changes. The developed worksheets contain simple experimental activities and discussions or assignments that are expected to enhance students' critical thinking skills and environmental literacy.

Task analysis in this study produced a science competency map that is useful for facilitating the preparation of science learning tools in accordance with the targeted competencies. The science competency map used in preparing the science learning tools is shown in Table 2.

Table 2. Science Competency Map

Component	Field of Study
Core Competencies	KI-3 Understands knowledge (factual, conceptual, and procedural) based on curiosity about science, technology, arts, and culture related to observable phenomena and events. KI-4 Trying, processing, and presenting in the concrete domain (using, analyzing, assembling, modifying, and creating) and the abstract domain (writing, reading, calculating, drawing, and composing) according to what is learned at school and other similar sources from a particular perspective/theory.
Basic Competencies	3.3 Explaining the concept of mixtures and pure substances (elements and compounds), physical and chemical properties, and physical and chemical changes in everyday life. 4.3 Presenting the results of investigations or work on the properties of solutions, physical changes and chemical changes, or the separation of mixtures.
Competency Achievement Indicators	3.3.1 Classifying the characteristics of matter 3.3.2 Explain the differences between elements, compounds, and mixtures 3.3.3 Analyzing methods of separating mixtures 3.3.4 Analyzing physical properties and chemical properties 3.3.5 Describing physical changes and chemical changes 4.3.1 Menyelidiki bahan-bahan alam yang dapat digunakan sebagai indikator alami 4.3.2 Making a report on the results of experiments on mixture separation
Material Topic	Classification of Matter and Its Changes
Sub-Material	1. Characteristics of matter, elements, compounds, and mixtures

Component	Field of Study
	2. Separation of mixtures
	3. Physical and chemical properties, physical and chemical changes
Orientation	Critical Thinking Skills and Environmental Literacy

The science competency map in Table 2 serves to assist in preparing assignments and materials in the development of science learning tools. The tasks presented, particularly in the Student Worksheet, are developed based on a scientific approach integrated with the local potential of Batik Sendang Lamongan, aiming to enhance students' critical thinking skills and environmental literacy in science learning, especially on the topic of Material Classification and Its Changes.

The concept analysis is developed to identify the basic concepts that will be presented in the science learning tools and used in the science learning process. The preparation of the concept analysis is based on the results of the task analysis previously conducted, which refers to the selected basic competencies. The materials selected to be included in the learning tools, particularly in the student worksheets, are then linked to produce a concept map. In this concept analysis, a concept map is produced as shown in Figure 1.

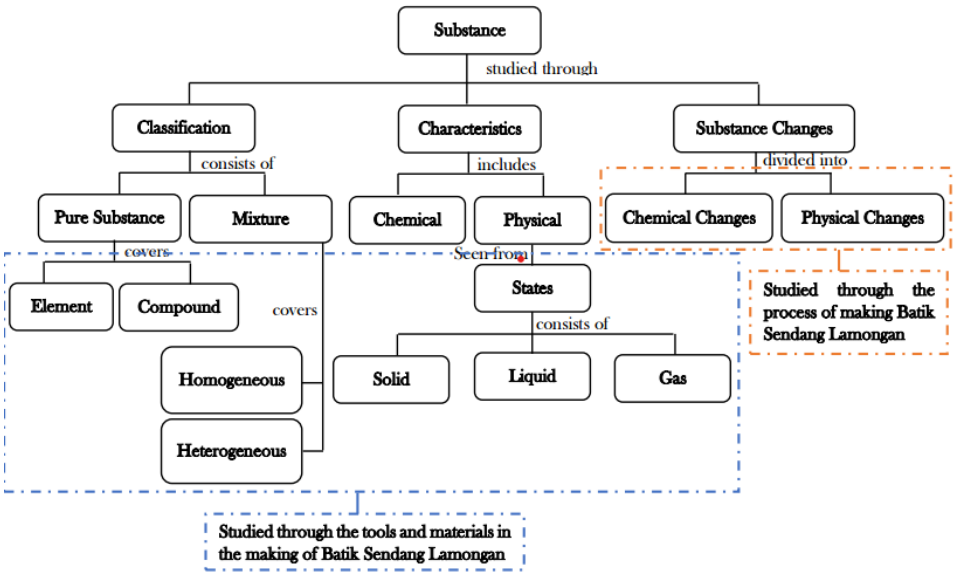


Figure 1. Material Scheme and Local Potential

As with concept analysis, the analysis of learning objectives is also based on the previous stage of analysis. The analysis of learning objectives is used as a basis for developing learning tools and evaluations that will support the development of those learning tools. The results of this learning objectives analysis produce several learning objectives to be achieved, including: 1) through simple experiments, students can classify the characteristics of materials according to theory; 2) through discussion, students can correctly explain the differences between elements, compounds, and mixtures. 3) Through simple experiments, students can explain methods of separating mixtures according to theory; 4) Through discussions, students can explain physical and chemical properties according to theory; 5) Through simple experiments, students can accurately describe physical and chemical changes; 6) Through simple experiments, students can correctly investigate natural materials that can be used as natural indicators; 7) Through discussions, students can correctly present reports on the results of mixture separation experiments.

The design (planning) stage consists of several steps, namely designing the format, selecting the media, designing the initial draft (syllabus, lesson plans, student worksheets, assessment instruments), and preparing research instruments. The purpose of this design stage

is to produce an initial draft of the science learning tools. The product design produced is adjusted according to the analysis results from the define stage.

The selection of the science learning device format developed in this study refers to the steps of science learning using a scientific approach. Furthermore, the material presented is integrated with the local potential of Batik Sendang Lamongan. The preparation of the developed science learning devices aims to improve students' critical thinking skills and environmental literacy. The developed science learning devices consist of a syllabus, lesson plans, student worksheets, and assessment sheets, the format of which is based on the prepared grid, and all of them are integrated with the local potential of Batik Sendang Lamongan.

The selection of media aims to choose the appropriate media to assist teachers in accompanying students during the science learning process. The selection of media is based on task analysis, concept analysis, and learning objectives. The chosen media is a simple experiment, especially those presented in the student worksheet in the form of printed media and developed based on the local potential of Sendang Lamongan Batik. The media used in the development of science learning tools, particularly in the worksheets, employs tools and materials as shown in Table 3.

Table 3. List of Media in the Science Student Worksheet

Part of LKPD	Media	Tools and Materials
Worksheet 3.1	Simple Experiment	Reference sources (7th grade Junior High School/MTs Science book and Batik Sendang Lamongan book), measuring cup, beaker, dropper pipette, spatula, blue and red litmus paper, turmeric extract, jati leaf extract, Hibiscus flower extract.
Worksheet 3.2	Simple Experiment	Beaker, measuring cup, mortar & pestle, dropper pipette, funnel, spatula, filter paper, turmeric, hibiscus flowers, teak leaves, distilled water, paper clips, pencil, colored markers.
Worksheet 3.3	Simple Experiment	Beaker, matchstick, spirit burner, tripod, gauze/plate, mortar & pestle, candle/batik wax, turmeric, sugar, ice cubes, distilled water, wood.

The initial draft design stage carried out in this study produced a design for the learning tools to be developed. The learning tools to be developed include a syllabus, lesson plans, student worksheets, and assessment instruments. The preparation of these tools is adjusted according to the framework based on the previously created grid.

The development of research instruments aims to measure students' learning outcomes after using the developed science learning tools. The instruments used in this study are product validation sheets to assess the feasibility of science learning tools according to expert lecturers and the practicality of the science learning tools according to science teachers, student worksheet readability sheets according to students, a test consisting of 10 essay questions used to measure students' critical thinking skills, and observation sheets to measure environmental literacy.

Product testing is a series of 4D stages used in this study, which includes the development and dissemination stages. This product testing aims to determine the effectiveness of the science learning device product in schools. The testing of the science learning device product that has been developed goes through several stages, including feasibility validation by expert lecturers, practicality by science teachers, readability by students, development testing, and then the dissemination stage.

The development stage is carried out to determine the feasibility of the developed science learning device product according to experts. In this development stage, the science learning device product that has been developed and approved by the supervising lecturer is then tested for feasibility by expert validators, practicality testing of the student worksheets by science teachers, limited trials, and development trials. Feasibility is a requirement that must be met by a science learning device product developed for use in learning. In this study, the feasibility of the developed science learning device was validated by two expert lecturer validators. The

purpose of validation by expert lecturers is to assess the feasibility of the developed science learning device product and to obtain suggestions that can be used as material to improve the created product. Validation was carried out on the aspects of content/material, appearance, and language.

The science learning device product was assessed/validated by two expert lecturers. The assessment by these expert validators was conducted using the previously prepared validation sheet guidelines. The results of the assessment by the expert lecturers were used to determine the feasibility benchmark of the science learning device according to the criteria that had been established or previously set. The results of the validation of the science learning device product by the expert lecturers also included suggestions used as materials to improve the developed science learning device product. The results of the feasibility analysis of the science learning device according to the expert lecturer validators are shown in Table 4.

Table 4. Analysis Results of the Feasibility Assessment of Science Learning Devices

No.	Component	Total Score (Score Max.)		Score	Categories
		Expert 1	Expert 2		
1.	Syllabus	15 (15)	15 (15)	A	Very Good
2.	Lesson Plan	14 (14)	14 (14)	A	Very Good
3.	Worksheet	13 (13)	13 (13)	A	Very Good
4.	Assessment Instrument	18 (18)	18 (18)	A	Very Good

Based on Table 4, it can be said that the assessment of science learning tools, which consist of the syllabus, lesson plans, student worksheets, and assessment instruments, received an A grade in the very good category. This means that the developed science learning tools are declared valid and can be empirically tested. In addition, expert suggestions were used to improve the developed science learning tools.

The practicality by science teachers aims to determine whether the science learning tools developed in this study are practical or not. In this study, the practicality of the science learning tools was assessed by two science teachers at SMP Negeri 5 Lamongan. In addition to the assessment, suggestions from the science teachers were also used as material to improve the developed science learning tools. The results of the analysis of the practicality of the science learning tools by the science teachers are presented in Table 5.

Table 5. Practicality Results of Science Learning Devices by Science Teachers

No.	Component	Total Score (Score Max.)		Score	Categories
		Teacher 1	Teacher 2		
1.	Syllabus	15 (15)	15 (15)	A	Very Good
2.	Lesson Plan	14 (14)	14 (14)	A	Very Good
3.	Worksheet	13 (13)	13 (13)	A	Very Good
4.	Assessment Instrument	18 (18)	18 (18)	A	Very Good

Based on Table 5, it can be said that the science learning device products developed are practically usable according to the science teachers, with a score of A in the very good category. Furthermore, a limited trial was conducted to obtain the readability value of the science worksheets that had been developed in the science learning device. The limited trial was carried out by providing the worksheets and asking 15 students at SMP Negeri 5 Lamongan to fill out a questionnaire and provide comments or suggestions, with 5 students in the low category, 5 students in the medium category, and 5 students in the high category. These categories were based on the students' test scores given by the science teacher.

Next, a field trial was conducted. The purpose of conducting the field trial was to determine the effectiveness of the developed science learning tools. The field trial was carried

out at SMP Negeri 5 Lamongan, Lamongan Regency, East Java. The study was conducted on two classes, namely class VII B with 30 students as the experimental class and class VII C with 32 students as the control class. The science learning tools used in the field trial were Draft 3, which had been revised according to the suggestions provided by expert validators and science teachers. The implementation of this field trial produced data that were used to analyze the effectiveness of science learning tools containing the local potential of Batik Sendang Lamongan in improving students' critical thinking skills and environmental literacy. The percentage of implementation of the science learning process incorporating the local potential of Batik Sendang Lamongan in the experimental class field trial is shown in Table 6.

Table 6. Implementation of Science Learning

No.	Meeting Number	Number of Activities	Observer Score		Average	Implementation Percentage (%)	Category
			1	2			
1	1	18	18	18	18	100	Very Good
2	2	18	17	17	17	94,44	Very Good
3	3	18	18	18	18	100	Very Good

The percentage of science learning implementation is above 90%, thus categorized as very good. The first meeting showed observational results that all activities were carried out. The second meeting showed that the activity that was not carried out was time management, which did not match the planned schedule. The third meeting showed that all activities were carried out.

The effectiveness of the science learning device product was obtained from the MANOVA test, which is a difference test between the experimental class and the control class with two variables, namely students' critical thinking skills and environmental literacy. The values obtained from the control class and the experimental class were analyzed for their increase in each variable. The steps taken were to process the data obtained from the research conducted in the field. The next step was to first carry out prerequisite tests by conducting normality and homogeneity tests.

Critical thinking skills are one of the variables used in this study. The step taken to determine the improvement in critical thinking skills is to compare the average N-gain of critical thinking skills between the control class and the experimental class. The average N-gain results obtained from this study are shown in Table 7.

Table 7. Comparison of Average N-Gain Values of Critical Thinking Skills

Class	Critical Thinking Skills		N-Gain
	Pretest	*Posttest*	
Experiment	47,17	68,58	0,41
Control	42,42	45,47	0,05

Based on Table 7, it can be said that the increase in critical thinking skills in the experimental class is higher than in the control class. The N-gain obtained for the experimental class is 0.41 with a moderate category, while the N-gain for the control class is 0.05 with a low category. Based on Table 7, a graph can also be created to show the difference in the improvement of critical thinking skills between the experimental class and the control class, as presented in Figure 2.

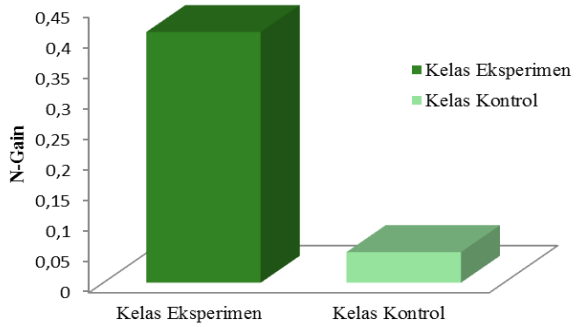


Figure 2. Graph of the N-Gain Differences in Critical Thinking Skills Between the Experimental Class and the Control Class

Furthermore, environmental literacy was also measured by comparing the average N-Gain of the experimental class and the control class, with the results shown in Table 8.

Table 8. Comparison of Average N-Gain in Environmental Literacy

Class	Environmental Literacy		N-Gain
	Pretest	*Posttest*	
Experiment	46,67	65,82	0,36
Control	38,54	53,13	0,24

From Table 8, a graph of the differences in students' environmental literacy N-Gain can be created, as shown in Figure 3.

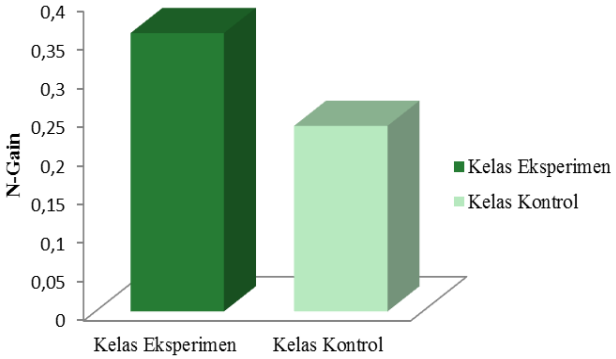


Figure 3. Graph of the Differences in N-Gain Environmental Literacy between the Experimental Class and the Control Class

The normality test aims to determine whether the distribution of data follows or approximates a normal distribution. The normality test is conducted as a prerequisite test for determining the statistical test to be used in the research. The normality test of the research results, which are in the form of critical thinking skills, can be determined through the significance value obtained from the Kolmogorov-Smirnov test using SPSS for Windows Version 16. The results of the normality test analysis are presented in Table 9.

Table 9. Normality Test Results

Test of Normality							
Data	Class	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Critical Thinking Skills	Experiment	.131	30	.197	.969	30	.520
	Control	.103	32	.200’	.969	32	.470
Environmental Literacy	Experiment	.140	30	.140	.931	30	.053
	Control	.136	32	.140	.935	32	.055

Based on Table 9, it can be seen that after testing with the Kolmogorov-Smirnov test, the significance values of the students' critical thinking skills and environmental literacy data were greater than the established significance level ($\alpha = 0.05$) in both the experimental and control

classes. This indicates that the critical thinking skills and environmental literacy data are normally distributed in both the experimental and control classes. The homogeneity test aims to determine the similarity of variances between the research data. This homogeneity test is similar to the normality test conducted previously, serving as a prerequisite before performing further tests on the research data. In this study, homogeneity analysis was tested using Levene's Test with SPSS for Windows Version 16. The data analysis obtained is presented in Table 10.

Table 10. Homogeneity Test Results by Levene's Test

Levene's Test of Equality of Error Variances*				
Data	F	df1	df2	Sig.
Critical Thinking Skills	1.193	1	60	.279
Environmental Literacy	.443	1	60	.508

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

Based on Table 10, the significance values of the data on students' critical thinking skills and environmental literacy are greater than the established significance level ($\alpha = 0.05$), which means that the data on critical thinking skills and environmental literacy are homogeneous in both the experimental and control classes. After the prerequisite tests were conducted using the normality test and the homogeneity test, the next step was to perform a correlation test between the dependent variables, the results of which are shown in Tables 11 and 12 below.

Table 11. Results of the Correlation Test for Pretest Data on Critical Thinking Skills and Environmental Literacy

Correlations			
		KBK_Pre	EL_1
KBK_Pre	Pearson Correlation	1	.251'
	Sig. (2-tailed)		.049
	N	62	62
EL-1	Pearson Correlation	.251'	1
	Sig. (2-tailed)	.049	
	N	62	62

Table 12. Results of the Posttest Data Correlation Test on Critical Thinking Skills and Environmental Literacy

Correlations			
		KBK_Post	EL_3
KBK_Post	Pearson Correlation	1	.298'
	Sig. (2-tailed)		.019
	N	62	62
EL-3	Pearson Correlation	.298'	1
	Sig. (2-tailed)	.019	
	N	62	62

Based on the results of the correlation test above, it can be said that the correlation obtained is positive. This is indicated by the Sig. (2-tailed) value of each variable correlation being smaller than the significance level set ($\alpha = 0.05$). Therefore, a MANOVA test can be conducted, which aims to test the existing hypotheses. The research hypothesis can be decided after performing the MANOVA test by looking at the significance values obtained. The results of the MANOVA analysis are presented in Table 13.

Table 13. Results Manova Test

Multivariate Tests[a]						
Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.971	9.825E2[a]	2.000	59.000	.000

	Wilks' Lambda	.029	9.825E2[a]	2.000	59.000	.000
	Hotelling's Trace	33.304	9.825E2[a]	2.000	59.000	.000
	Roy's Largest Root	33.304	9.825E2[a]	2.000	59.000	.000
Class	Pillai's Trace	.506	30.239[a]	2.000	59.000	.000
	Wilks' Lambda	..494	30.239[a]	2.000	59.000	.000
	Hotelling's Trace	1.025	30.239[a]	2.000	59.000	.000
	Roy's Largest Root	1.025	30.239[a]	2.000	59.000	.000

Based on Table 13, for the class effect (experimental vs. control), the Wilks' Lambda value obtained was 0.494, indicating that approximately 49.4% of the variance in the combination of dependent variables (critical thinking skills and environmental literacy) cannot be explained by group differences, or in other words, there is a fairly strong effect of the treatment. The F value = 30.239 with degrees of freedom (df) = (2, 59) indicates that the differences between groups are multivariately significant. This is reinforced by the significance value (Sig.) = 0.000 (< 0.05), so it can be concluded that there is a significant difference between the experimental and control classes simultaneously on both dependent variables. In terms of effect size, a Wilks' Lambda value closer to 0 than 1 indicates a larger effect; with a value of 0.494, it can be interpreted that the treatment effect falls into the moderate to strong category. In addition, an Observed Power = 1.000 indicates that the test has a very high ability to detect existing differences. Thus, the developed science learning tools have been proven to have a significant simultaneous effect on students' critical thinking skills and environmental literacy.

The research results obtained are also in line with several relevant studies, such as the study conducted by Wilujeng et al. (2017) entitled Development of Science Learning Devices Based on Local Potential to Improve Nature of Science (NOS) Achievement. The study by Anisa (2016) is entitled Jepara's Local Potential as a Basis for Developing Science Learning Devices for Junior High Schools to Improve Students' Critical Thinking Skills and Entrepreneurial Attitudes. The discussion of the research results shows that the improvement of students' critical thinking skills and environmental literacy in the experimental class is inseparable from a strong theoretical foundation, including the perspective of constructivist learning theory. The natural science learning tools based on Batik Sendang Lamongan enable students to actively build knowledge through direct experience and interaction with authentic learning environments. The designed learning activities, such as observing batik patterns, analyzing dye materials, and discussing the environmental impact of the batik production process, encourage students to connect scientific concepts with real-world phenomena. This aligns with the constructivist view that knowledge is built through an active, reflective, and experience-based process (Schunk, 2019; Fosnot & Perry, 2018). The implementation of place-based education in this study has been proven to make a significant contribution to improving students' environmental literacy. By integrating the potential of Lokal Batik Sendang Lamongan into science learning, students are encouraged to understand the connection between science, local culture, and environmental issues around them. Learning becomes more contextual because it is rooted in the realities of students' lives, thereby increasing their engagement and ecological awareness. These findings support previous research results which state that the place-based approach can enhance both conceptual understanding and environmental concern (Ardoin et al., 2020; Semken et al., 2017).

Moreover, the success of this learning device is also influenced by the implementation of pedagogy that is responsive to culture (culturally responsive pedagogy). The integration of Batik Sendang Lamongan as part of the local cultural identity makes learning more inclusive and relevant to students' backgrounds. Students feel closer to the learning material because it is directly related to the culture they are familiar with, thereby increasing motivation and participation in learning. This pedagogy emphasizes the importance of accommodating students' values, experiences, and cultural identities in the learning process. In this context, learning not only transfers scientific knowledge but also strengthens students' cultural identity and social

awareness (Gay, 2018; Hammond, 2015). Therefore, science learning tools incorporating the local potential of Batik Sendang Lamongan, based on the results and data analysis conducted through pretests, posttests, and observations, can be considered effective as science learning tools that help teachers train students' critical thinking skills and environmental literacy.

CONCLUSION

Based on the results of the research and development that has been conducted, it can be concluded that the science learning device incorporating the local potential of Batik Sendang Lamongan is feasible to use for improving students' critical thinking skills and environmental literacy, with a very good category. In addition, the science learning device incorporating the local potential of Batik Sendang Lamongan is significantly effective in improving students' critical thinking skills and environmental literacy. The findings from this study also provide important implications for the development of science education. In terms of curriculum design, these results emphasize the need for the integration of local contexts, constructivist approaches, and environmental literacy so that learning becomes more meaningful, contextual, and promotes higher-order thinking skills. In addition, the developed tools have the potential for application in various regions because they can be adapted to the local potential of each area, thereby supporting relevant learning while strengthening students' cultural identity and environmental awareness. This study also has limitations regarding the relatively small sample size and being limited to one school, so similar research needs to be further tested through studies with larger and more diverse samples.

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