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Innovation in Acid-Base Learning (PasamBa) through Ecoprint Batik as a Contextual Strategy to Improve Understanding of Fashion Design Students in SMK

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Abstract: This study aims to test the effectiveness of PAsamBa (Acid-Base Learning) learning innovation integrated with *ecoprint batik practice* in improving conceptual understanding and vocational skills of eleventh-grade students in the Fashion Design expertise program at Vocational High Schools (SMK). The acid-base concept has direct relevance to textile skill processes such as mordanting, color fixation, and pH stability of natural dyes, which are important in sustainable fabric dyeing. The study used a one-group pretest-posttest design involving 73 students from three vocational high schools in Aceh. The instruments included a 20-item acid-base concept understanding test (α = 0.86) and a vocational skills rubric that assessed procedural accuracy, color stability, and *ecoprint pattern quality*. The results showed a significant increase ($t(72) = 12.86$; $p < 0.001$), with the average score increasing from 43.69 to 80.53 and an *N-gain value* of 0.67 (medium-high category, approaching high). Students' vocational skills also improved, with an average process score of 3.49 and a product score of 3.41 (scale 4). These results demonstrate that the PAsamBa–Ecoprint approach effectively integrates chemistry learning with contextual textile practices to strengthen students' conceptual understanding and readiness for the creative fashion industry.

Keywords: Acid-base learning; Contextual learning; Ecoprint batik; Fashion design; Vocational competence

Introduction

The concept of acids and bases is a core component of the chemistry curriculum. However, this concept is often perceived by students as abstract, particularly in the context of vocational education (Agustina et al., 2020). This challenge is even more pronounced in the Fashion Design expertise program at Vocational High Schools (SMK Tata Busana), where students require a strong connection between scientific concepts and textile practices to support their future professional competencies (Asli et al., 2023). At the same time, vocational education emphasizes the integration of cognitive knowledge and technical skills to prepare graduates who are ready for work or entrepreneurship (Haryani et al., 2021). Although vocational high school graduates are expected to be "work-ready," national employment data show a different situation. According to Statistics Indonesia (BPS) in 2024 (data as of February 6, 2025), the Open Unemployment Rate (TPT) for vocational high school graduates remained higher (9.01%) than for high school graduates (7.05%), indicating a persistent gap between school competencies and industry needs.

One contributing factor is the limited integration of science learning with creative industry skills relevant to specific areas of expertise. In the context of Fashion Design, the textile and fashion subsector contributes significantly to Indonesia's creative economy, accounting for 7.8% of the national creative economy GDP (Kementerian Pariwisata dan Ekonomi Kreatif, 2023). This indicates that strengthening the scientific foundation relevant to textile processes, such as color fixation, mordanting, and the stability of natural dyes

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(Che & Yang, 2022; Pinheiro et al., 2019) is crucial for enhancing students' vocational readiness.

Acid-base material is known to be conceptually challenging due to its abstract representation and numerous misconceptions, such as equating 'strong-weak' with 'concentrated-dilute' or considering pH as the sole determinant of acid-base strength (Ningrum et al., 2022). These misconceptions are still found among students and prospective teachers, thus reinforcing the need for contextual and meaningful learning approaches (Widihastuti et al., 2023). Context-based chemistry learning has been shown to improve conceptual understanding and scientific literacy by linking abstract concepts to real-life situations (Aji et al., 2024; Febriana et al., 2025). However, this approach remains underutilized in vocational education, particularly in fields closely related to textile and fashion practices (Royhan et al., 2025).

The ecoprint technique, which is the process of transferring natural pigments from plant parts (Majapahit et al., 2025) to fabric through pounding techniques assisted by fixatives (mordants), offers a highly contextual medium for learning acid-base concepts (Sholikhah et al., 2022). Variations in mordant type, dye composition, and process conditions affect color fastness and pattern quality, making ecoprint an authentic platform for exploring chemical principles in textile practice (Hasanah et al., 2024; Nurmasitah et al., 2022). The mordanting and color fixing process in ecoprinting involves chemical reactions that can be directly linked to the concepts of pH, acid-base strength, and compound stability (Diva & Novrita, 2023). Furthermore, the use of natural indicators, such as anthocyanin-rich plants (Riyanti et al., 2022), allows students to observe color changes due to pH differences, thus concretizing acid-base reactions through direct experience (Qomariah et al., 2022).

In vocational education, project-based learning (PjBL) has been shown to be effective in enhancing work skills, collaboration, and creativity (Megayanti et al., 2020; Purnamasari et al., 2025). When applied to a Fashion Design program, PjBL strengthens students' practical competencies in textile processing, as well as supporting the development of relevant Generic Science Skills for problem-solving in the workplace (Doyan et al., 2025). The integration of PjBL with ecoprinting not only encourages environmentally friendly practices but also aligns with green chemistry and ethnoscience perspectives, which emphasize the value of using natural dyes and sustainable textile production (Budiman et al., 2023).

However, despite existing research on PjBL, ecoprint techniques, and the use of natural indicators, no research has specifically examined the effectiveness of natural indicator-based ecoprint as a contextual medium to improve conceptual understanding of acids and bases as well as vocational competencies in Fashion Design programs at vocational high schools. Previous studies have addressed these components separately, but the explicit integration of chemistry learning and ecoprinting as a workplace-relevant textile practice has not been adequately explored.

Therefore, this study introduces an innovative approach, PAsamBa (Acid-Base Learning), integrated with ecoprint batik practices to bridge this gap. This research aims to strengthen students' conceptual understanding while enhancing their vocational readiness to align with the needs of the creative fashion industry.

Method

This study used a quasi-experimental design with a one-group pretest–posttest model applied to 11th grade students of the Fashion Design expertise program at three vocational high schools in Aceh, namely SMKN 1 Sigli, SMKN Meukek, and SMKN 1 Mesjid Raya with a total of 73 students. The study was conducted in three stages, namely a pretest to measure the initial understanding of the acid–base concept, the implementation of PAsamBa learning integrated with ecoprint practice, and a posttest to assess the increase in conceptual understanding after the treatment. The entire research process is summarized in a flowchart that describes the stages of instrument preparation, learning implementation, vocational skills observation, and data analysis. The following is a flowchart in the study.

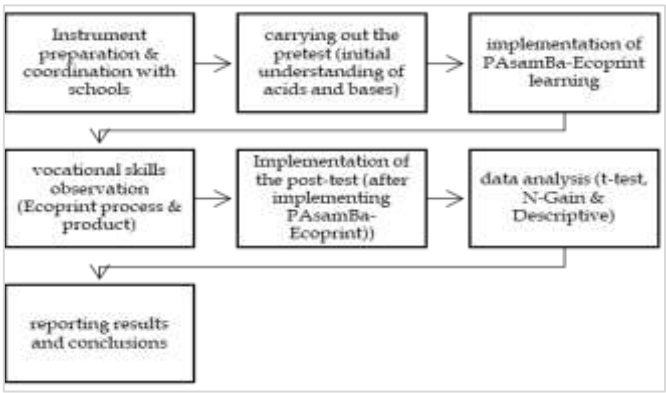

Figure 1. Research flow diagram

The conceptual understanding instrument was a 20-item multiple-choice test validated by three experts using the Content Validity Ratio (CVR) approach and had a Cronbach Alpha reliability of 0.86. This study also used a vocational skills instrument in the form of a structured observation sheet with an ecoprint process and product assessment rubric. The process rubric assessed procedural accuracy, such as the application of

mordant, the arrangement of materials on the fabric, and the beating or steaming technique. The product rubric assessed the sharpness of the pattern, color stability, and neatness of the work. The assessment was carried out by two independent observers. The level of inter-rater agreement was calculated using Cohen's κ coefficient. The student engagement observation sheet was used to support qualitative data regarding student collaboration and independence during the practice.

Internal validity threats inherent in a single-group design, such as history, maturation, and testing effects, were minimized by equalizing the duration and sequence of learning across schools and using parallel pretest–posttest items. Quantitative data were analyzed using the Kolmogorov–Smirnov normality test, Levene's homogeneity test, and paired-sample t-test, and the N-gain value was calculated to determine learning effectiveness. Meanwhile, vocational skills data were analyzed descriptively to examine changes in the quality of students' ecoprint processes and products.

Result and Discussion

The learning outcomes data of students at SMKN 1 Sigli, SMKN Meukek, and SMKN 1 Mesjid Raya that were analyzed were the results of pretests and posttests. This was done to assess students' abilities in understanding acid-base material through ecoprinting practices. Based on the analysis of the pretest and posttest results of the acid-base material for the three schools, the findings are as follows:

Results of Pretest Analysis of SMKN 1 Sigli, SMKN Meukek, and SMKN 1 Mesjid Raya

A pretest was administered at the first meeting before the ecoprint batik practice was implemented in the three research schools. The analysis showed that the three schools had varying levels of conceptual understanding before implementing the ecoprint practice as a contextual innovation in understanding acid-base learning (PAsamBA). This can be seen in Table 1.

Table 1. Average Pretest Scores of SMKN 1 Sigli, SMKN Meukek, and SMKN 1 Mesjid Raya

School	Pretest average
SMKN 1 Sigli	44.07
SMKN Meukek	44.00
SMKN1 Mesjid Raya	43.00

The pretest results from the three schools showed that students' initial understanding of acid-base learning (PAsamBa) was still relatively low, still below the Minimum Completion Criteria (KKM), which indicated that most students had not mastered the acid-base material before innovative learning was implemented.

The low pretest scores can be attributed to several factors. First, the concepts of acids and bases are abstract and difficult to understand through classroom learning alone (Fitri et al., 2025; Jauza Nareswari et al., 2024). Second, most vocational high school students are more accustomed to practical skills-based learning, so they tend to struggle when confronted with pure chemistry concepts (Sudarmin et al., 2023). Third, the use of conventional learning media previously did not provide adequate contextual representation, leaving students with limited prior knowledge (Anugrah, 2021). Furthermore, the low pretest scores for chemistry students were also caused by the lack of connection between theory and everyday life. This highlights the importance of contextual learning strategies that connect chemistry concepts with students' real-life experiences (Assi & Cohen, 2024). It is hoped that the innovative acid-base learning process through Batik Ecoprint practices can bridge this gap by providing a contextual, engaging, and relevant learning experience for the fashion design field.

Posttest Analysis Results of SMKN 1 Sigli, SMKN Meukek, and SMKN 1 Mesjid Raya

Post-test questions were administered after the ecoprint batik practice was carried out at the three research schools. This test aimed to assess students' ability levels related to acid-based materials through the application of ecoprint practice. The analysis of post-test scores showed that students in the three schools had different levels of conceptual understanding, resulting in different learning outcomes. For more information, please see Table 2.

Table 2. Average Posttest Scores of SMKN 1 Sigli, SMKN Meukek, and SMKN 1 Mesjid Raya

School	Pretest average
SMKN 1 Sigli	80.74
SMKN Meukek	80.60
SMKN1 Mesjid Raya	80.25

Posttest results from all three schools showed significant improvements compared to pretest scores. This improvement indicates that Acid-Base (PAsamBa) learning through ecoprinting practices is effective in helping students understand previously difficult concepts. This contextualization also impacts knowledge retention. A study on vocational high school students in fashion design showed that project-based learning on eco-friendly fashion increased post-test scores by 28–35 points and retained 80% of the knowledge after one month (Ernawati et al., 2023).

Similar results were found in this study, indicating that a direct connection to vocational competencies makes it easier for students to remember and reuse concepts (Yusaerah et al., 2023). From a science education perspective, this approach integrates Science Literacy and Vocational Skills (Nadir et al., 2022). The ecoprint products produced by students serve not only as a means to evaluate learning outcomes but also as concrete examples of the application of chemistry concepts in sustainable creative industries, in line with the green chemistry trend in the textile industry (Pratiwi et al., 2024).

Furthermore, the paired-sample t- test results showed a significant difference between the pretest and posttest, indicating that this learning was effective in improving students' understanding of acid-base concepts. The following table shows the paired-sample t-test results from the three schools.

Table 3. Paired-Sample T-Test Results for SMKN 1 Sigli, SMKN Meukek, and SMKN 1 Mesjid Raya

School	t	Sig. (2-tailed)
SMKN Meukek	-30,119	.000
SMKN1 Mesjid Raya	-25,300	.000
SMKN 1 Sigli	-32,383	.000

The test results indicate that students are able to transfer knowledge from the practical activities into test answers. This indicates that contextual learning has a positive impact on students' memory, understanding, and analytical skills (Samani et al., 2019; Juniar & Tarigan, 2024). Thus, the higher posttest results compared to the pretest provide empirical evidence that integrating Acid-Base Learning through Ecoprint Batik is an innovative learning strategy that can be widely implemented in Fashion Design Vocational Schools.

Based on the results of the score increase and N-gain, it also shows that the implementation of ecoprint practices in acid-base learning (PAsamBa) provides pedagogical benefits. The N-gain results can be seen in Figure 2.

The results of this study indicate a significant increase in the understanding of acid-base concepts in all three schools. Based on the analysis of the data, it can be said that through ecoprinting activities, students can directly observe how natural substances from leaves, flowers, and plant-based dyes change color when exposed to acid or base treatment. This experience provides students with the opportunity to connect abstract concepts with real-world phenomena, making their understanding more meaningful (Irdalisa et al., 2024). Furthermore, student involvement in the ecoprinting batik practical activities makes the learning process more enjoyable and challenging (Sugiastutih & Restian, 2025). This is also in line with research stating that real-world practice-based learning can increase student learning motivation and strengthen conceptual understanding (Nur'aini et al., 2024). In other words, the use of ecoprinting not only trains students' skills in fashion design but also enriches their understanding of chemistry.

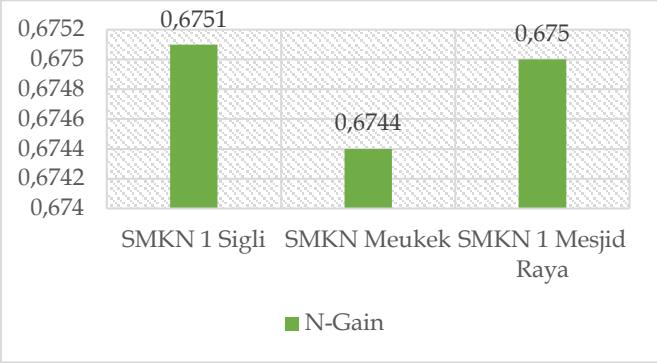

Figure 2. Average n-gain scores across three schools

Vocational Skills of Vocational High School Students

Learning chemistry using the ecoprint method helped students in their work. Observations of the activity showed that students were able to carry out each stage of the process independently and accurately, from preparing the fabric, making the mordant solution, preparing natural materials such as leaves and flowers, to steaming and drying the fabric. The process assessment results demonstrated strong procedural skills and good implementation of work safety, with an average score of 3.49 on a scale of 4.

The ecoprinted fabrics created by the students demonstrated adequate product quality, with neatness, pattern sharpness, and good colorfastness (3.41 on a scale of 4). This product not only helps students learn but also has aesthetic value and offers entrepreneurial opportunities in the textile creative industry (Aryani et al., 2024; Purwanto et al., 2024). These results align with research by Nida et al. (2024), which suggests that ecoprinting can be a useful tool for connecting chemical knowledge with sustainable clothing manufacturing techniques.

Figure 3. Arrangement of leaf and flower motifs on the cloth before steaming

Figure 4. The process of rolling and steaming ecoprint fabric

Figure 5. Stage of opening the cloth after steaming

Figure 6. Final result of students' ecoprint products

When students engage in this ecoprinting process, they directly observe the color changes of the leaves/prints on the fabric due to the use of fixative solutions with different pH levels (e.g., alum with a pH close to neutral, lime water which is alkaline). This activity triggers three multisensory learning experiences: first, visual, where students can observe the striking color changes of the fabric, which is a strong stimulus for differentiating pH (Wulandari & Mahmudah, 2024). The second motor skill involves hand movements in preparing materials, arranging leaves, and the heating process, which connects concepts with procedural memory. And the third cognitive aspect is that students connect observations with theoretical concepts of acids and bases, strengthening associations and retention (Araripe & Zuin Zeidler, 2024).

Other research findings also confirm that natural-material-based approaches are not only environmentally friendly (Jorge et al., 2025; Ziad et al., 2024) but also have high visual appeal that can increase student engagement and help build the science process (Soesilowati et al., 2024). This is in line with the Contextual Teaching and Learning (CTL) framework, where relevant and real-world learning experiences can transform abstract concepts into knowledge that is easier to understand and remember (Shabrina et al., 2025).

Thus, the successful concretization of abstract concepts through natural indicators in ecoprint batik activities not only provides aesthetic and vocational experiences, but also proves pedagogically effective in strengthening vocational high school students' understanding of acid-base concepts. In this study, this transfer was clearly seen in the students' ability to explain the reasons for color changes in ecoprints based on differences in fixative pH, even though they had never previously associated chemistry with textile techniques (Benli, 2024).

Conclusion

This study concludes that the PAsamBa (Acid-Base Learning) learning model integrated with natural indicator-based batik ecoprinting practices has been proven effective in improving conceptual understanding and strengthening vocational skills of Fashion Design Vocational High School students. The analysis results showed a significant increase between pretest and posttest scores ($p < 0.001$) with an average N-gain of 0.67, which is included in the medium-high and approaching high category. This learning not only helps students understand the acid-base concept contextually through mordanting and natural color fixation activities, but also trains process skills and produces good quality ecoprint products (process score 3.49 and product 3.41). In addition, this approach provides ethnoscience and environmental benefits because it utilizes environmentally friendly natural dyes and elevates the value of local wisdom in sustainable textile practices. The PAsamBa-Ecoprint model can be used as an alternative project-based contextual chemistry learning in vocational high schools to integrate science and vocational skills in a balanced manner

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Conceptualisation, methodology, validation, writing, review and editing, original draft preparation and visualization, MF; formal analysis and data curation, and supervision, resources, MH All authors have read and approved the published version of the manuscript.

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