UNESA Journal of Chemical Education *ISSN: 2252-9454*
Vol. 15, No. 2, pp. 157–164, May 2026

IMPLEMENTATION OF PROJECT-BASED LEARNING WITH AN EDU-ECOPRENEURSHIP FOCUS: STUDENTS' PRACTICAL SKILLS AND THE QUALITY OF BAR SOAP MADE FROM USED COOKING OIL WITH PAPAYA EXTRACT

Aulia Nur Alfiannissa[1]*, Tri Wahyuni[2], and Findiyani Ernawati Asih[1]

[1]Department of Chemistry, FMNS, Universitas Negeri Surabaya

[2]Laboratory Testing Analyse, SMKN 1 Cerme

e-mail: aulia.23093@mhs.unesa.ac.id

Abstract

Used cooking oil is one of the household wastes that can be utilized as a raw material for solid soap production while supporting environmental sustainability efforts. This study explored the implementation of Project-Based Learning (PjBL) integrated with edu-ecopreneurship through a project involving the production of solid soap from used cooking oil with the addition of papaya extract. The study involved 72 tenth-grade students from the program of Laboratory Analysis and Testing (LAT) at a vocational high school in Gresik and employed a quantitative descriptive approach with a one-shot case study design. Data were collected through observations of students' practical skills and quality testing of the soap products, including pH value, residual alkali content, density, and foam stability. The observations showed that students generally demonstrated good practical skills during project implementation, particularly in preparing materials, following procedures, and applying laboratory safety practices. The soap produced by both classes exhibited relatively similar characteristics, with satisfactory density and foam stability; however, the pH values and residual alkali content indicated that the saponification process had not yet reached optimal conditions. The project provided opportunities for students to apply chemistry concepts through direct experience while utilizing waste materials with potential economic value, making learning activities more relevant to real-life environmental issues.

Keyword: edu-ecopreneurship, project-based learning, chemistry, bar soap, used cooking oil

INTRODUCTION

The increasing amount of used cooking oil generated by households remains a common problem in Indonesia [1]. This issue is not only related to the ever-growing volume of waste but also to the fact that its management has not yet been optimized. Disposing of used cooking oil directly into the environment can cause soil and water pollution and degrade the quality of the surrounding environment [2]. In addition to its environmental impacts, the reuse of used cooking oil as a food ingredient should also be avoided because repeated heating can produce degradation byproducts that may pose health risks [3].

Despite these various impacts, used cooking oil still holds potential for being repurposed into more useful products [4]. One such application is the production of bar soap through the saponification process. In this process, the fatty acids contained in the oil react with a strong base to produce soap and glycerol [5]. Processing used cooking oil into soap also aligns with the principles of the circular economy, as waste that was previously unused can be reprocessed into a product with practical value [6].

The characteristics of the resulting soap are influenced not only by the main raw material but also by the additives used in its formulation. One natural ingredient with potential for use as an additive in the production of bar soap is papaya extract (Carica papaya L.). Papaya pulp contains antioxidants such as saponins and flavonoids, which play a role in skin regeneration through collagen synthesis and the formation of new tissue by fibroblasts [7]. Antioxidants also help suppress the activity of free radicals, which can damage skin DNA, leading to dry skin and wrinkles.

This initiative is closely aligned with the sustainable development agenda, particularly SDG 6 on clean water and sanitation, as part of efforts to reduce water pollution. Additionally, this initiative supports SDG 12, which focuses on resource management and promotes more environmentally responsible consumption and production patterns.

In vocational education, project-based learning has proven effective in enhancing students' skills [8]. This approach also supports the development of pre-vocational skills that are relevant to workplace needs [9]. Its implementation helps motivate students to experiment, gain experience, enhance their creativity, and learn new things while producing valuable learning outcomes [10].

This implementation is reflected in a project to produce solid soap made from used cooking oil and papaya extract by 10th-grade students in the program of Laboratory Analysis and Testing (LAT) at a vocational high school in Gresik, which integrates an environment-based edu-ecopreneurship approach with entrepreneurship. This activity also supports SDG 4 (*Quality Education*) through contextual learning focused on developing 21st-century skills, thereby not only contributing to environmental sustainability but also strengthening students' competencies and entrepreneurial spirit.

The implementation of Project-Based Learning (PjBL) has been widely reported to enhance students' critical thinking skills, problem-solving abilities, and competencies in both science education and vocational education [11]. In addition, the ecopreneurship approach is also known to foster environmental awareness and an entrepreneurial spirit through the sustainable use of resources [12]. However, most of these studies focus on the learning process or the development of student competencies, while research on the quality of the products produced as learning outcomes remains limited [13]. On the other hand, research on soap making from used cooking oil generally emphasizes only the physicochemical characteristics of the product without linking it to learning implementation in schools [14]. Therefore, this study was conducted to examine the implementation of PjBL integrated with edu-ecopreneurship through the production of solid soap from used cooking oil with papaya extract in the vocational chemistry learning.

Based on the above description, this study aims to: (1) implement an integrated Project-Based Learning (PjBL) model incorporating edu-ecopreneurship through a project to produce solid soap made from used cooking oil with added papaya extract among 10th-grade students in the LAT class; (2) evaluate students' practical skills during the project implementation as a manifestation of the integration of chemistry and environment-based entrepreneurship competencies; and (3) describe the quality of the solid soap produced as an outcome of project-based learning.

METHOD

This study is a quantitative descriptive study with a pre-experimental design using a one-shot case study approach. This approach was chosen because the study aims to describe the implementation of Project-Based Learning (PjBL) integrated with edu-ecopreneurship, evaluate students' practical skills during the project implementation, and describe the quality of the solid soap product produced as a learning outcome. This study does not constitute a pure experiment because it does not involve a control group or subject randomization. A pre-experimental design was chosen because the study was conducted on naturally formed groups (intact groups), namely classes LAT 1 and LAT 2. The data obtained were used to describe students' practical skills during project implementation as well as the quality of the solid soap produced in project-based learning.

The study was conducted on April 22, 2026, at a state vocational high school in Gresik, East Java. The research subjects consisted of 72 tenth-grade students in the LAT program, divided into two classes: LAT 1 (n = 36) and LAT 2 (n = 36). The sampling technique used was total sampling, meaning all 10th-grade LAT students were included as research subjects. During the project activity, students produced solid soap made from used cooking oil with various added ingredients. However, the data analyzed in this study came from the group that produced solid soap with added papaya extract, as this aligned with the research focus.

The learning process was based on the Project-Based Learning (PjBL) model integrated with the edu-ecopreneurship approach through a project to produce solid soap made from used cooking oil with the addition of papaya extract. The implementation of PjBL was carried out through six stages: determining the fundamental question, project planning, scheduling, monitoring project implementation, product testing and presentation, and evaluation of the learning experience. The project provided students with opportunities to engage in the utilization of waste cooking oil as a raw material for solid soap production. Through this process, students participated in activities that demonstrated the potential of waste materials to be converted into useful products with added value.

The study focused on the implementation of Project-Based Learning (PjBL) integrated with edu-ecopreneurship in a soap-making project. Observations were conducted to describe students' practical skills during project implementation, while product testing was carried out to evaluate the quality of the resulting solid soap. Product quality was evaluated based on physicochemical parameters, including pH value, free alkali content, density, and foam height.

Data collection was conducted through observation of students' practical skills during project implementation and testing of the quality of the solid soap produced. Practical skills were observed using an observation sheet covering the stages of PjBL implementation. Meanwhile, soap quality was evaluated by testing the pH value using a pH meter, free alkali content using phenolphthalein (PP) indicator, soap density, and the height of the foam formed. The test results were then analyzed based on predetermined assessment criteria.

Table 1. Practical Skills Assessment Instrument

No	Aspects Assessed
1	Preparation of tools and materials
2	Accuracy of work procedures
3	Use of laboratory equipment
4	Occupational safety and health (OSH)
5	Data observation and recording
6	Cooperation and communication
7	Problem-solving
8	Project Presentation

Table 2. Practical Skills Assessment Criteria

Score Range	Category
4,00-3,26	Excellent
3,25-2,51	Good
2,50-1,76	Fair
1,75-1,00	Poor

The assessment of students' practical skills was conducted through observation during the implementation of the project to make solid soap from used cooking oil with the addition of papaya extract. Each aspect was rated on a 1–4 scale, with a score of 4 indicating the "very good" category and a score of 1 indicating the "poor" category. The scores obtained are then calculated to determine the level of students' practical skills during the implementation of Project-Based Learning (PjBL) integrated with edu-ecopreneurship.

The evaluation criteria for each parameter—namely pH, free alkali residue, hardness, and foaming capacity are presented in Table 3, Table 4, Table 5, and Table 6, respectively.

Table 3. pH Value Criteria

Score	pH Range	Description
3	8–10	Very suitable
2	11–12	Less suitable
1	>12.0	Not suitable

Table 4. Residual Alkali Criteria

Score	Color	Description
3	Colorless	None
2	Light pink	A little
1	Deep pink	A lot

Table 5. Density Criteria

Score	Description
3	Very dense
2	Fair
1	Not dense

Table 6. Foam Power Criteria

Score	Foam Difference (cm)	Description
3	<1.0	Stable
2	1.1–3	Fairly stable
1	>3.0	Disappears quickly

The data obtained were analyzed using quantitative descriptive methods. Data on students' practical skills were presented as mean scores and achievement categories, while data on the quality of the bar soap were presented as the results of soap quality tests, including pH, free alkali content, density, and foam height. Next, the results obtained were described to illustrate the success of implementing PjBL integrated with edu-ecopreneurship and the quality of the products produced.

RESULT AND DISCUSSION

The results of the observation of students' practical skills during the implementation of the project to make solid soap from used cooking oil with the addition of papaya extract are presented in Table 7.

Table 7. Results of Student Practical Skill Assessment Observations

No	Aspects Assessed	LAT 1	Category	LAT 2	Category
1	Preparation of tools and materials	3.67	Excellent	3.56	Very good
2	Accuracy of work procedures	3.44	Good	3.39	Good
3	Use of laboratory equipment	3.61	Very good	3.50	Very good
4	Occupational safety and health (OSH)	3.72	Very good	3.67	Very good
5	Data observation and recording	3.39	Good	3.28	Good
6	Teamwork and communication	3.78	Very good	3.72	Very good
7	Problem-solving	3.28	Good	3.17	Good
8	Project results presentation	3.50	Very good	3.46	Good
	Average	3.55	Very good	3.46	Good

Based on the observation results, students in LAT 1 achieved an average score of 3,55, which falls into the "very good" category, while students in LAT 2 achieved an average score of 3,46, also falling into the "very good" category. The aspects that received the highest scores in both classes were cooperation and communication, as well as occupational safety and health (OSH). This indicates that students were able to collaborate effectively in groups and apply occupational safety procedures during project implementation.

Among the assessed aspects, problem-solving, observation, and data recording showed lower average scores than the others. During the project, several students still needed assistance in identifying the causes of problems that occurred during soap production and in documenting their observations in an organized manner. However, most students were able to perform laboratory activities according to the procedures provided, resulting in an overall practical skills category of excellent.

The quality testing results of the solid soap produced from used cooking oil and papaya extract are summarized in Table 8.

Table 8. Quality Test Results for Solid Soap

Parameter	LAT 1	LAT 2
pH Value	12.0 (Basic)	12.2 (Basic)
Residual Alkali	High	High
Density	Moderate	Moderate
Foam	7.0 → 6.9 cm	4.0 → 3.5 cm

The results presented in Table 8 reveal variations in the quality of the solid soap produced by the LAT 1 and LAT 2 classes. Despite using the same materials and procedures, differences were observed in several testing parameters. Such differences may be associated with variations in laboratory practices during the project, including ingredient measurement, mixing uniformity, temperature control, and compliance with the working procedures.

 ISSN: 2252-9454

These findings suggest that the final characteristics of the soap were affected by both the production process and the students' performance during project implementation.

1. **pH Test**

Table 9. pH Test Results

Class	pH	Remarks
LAT 1	12.0	Not suitable
LAT 2	12.2	Not suitable

Table 9 shows that the pH values of the soap samples from LAT 1 and LAT 2 were 12.0 and 12.2, respectively. These values were higher than the recommended range used in this study, indicating that the resulting soap was still strongly alkaline.

One possible explanation for this result is the presence of excess NaOH during soap production. In the saponification process, NaOH reacts with the fatty acids contained in used cooking oil to form soap and glycerol. When the reaction does not proceed completely, a portion of the alkali may remain in the product, leading to a higher pH value. This condition suggests that the formulation or processing conditions may require further optimization to obtain soap with a pH closer to the desired range.

2. **Free Alkali Residue Test**

Table 10. Free Alkali Residue Test Result

Class	Color	Description
LAT 1	Deep pink	A lot
LAT 2	Deep pink	A lot

The residual alkali content was evaluated using phenolphthalein (PP) indicator, and the results are presented in Table 10. Both LAT 1 and LAT 2 soap samples were classified in the high residual alkali category, as indicated by the formation of a dark pink color during testing. The presence of residual alkali suggests that part of the NaOH remained in the final product after the soap-making process.

Several factors may have contributed to this result, including inaccuracies in the proportion of oil and NaOH, insufficient mixing, or reaction conditions that were not fully optimized. As a consequence, the conversion of the oil into soap may not have proceeded completely, leaving free alkali in the product.

The presence of excess alkali is undesirable because it may affect the safety of the soap when applied to the skin, particularly for sensitive users. The results obtained in this study suggest that further adjustments to the formulation and production process are still required. In addition, the curing stage may not have been long enough to reduce the remaining alkali content, as this stage allows further stabilization of the soap before use. Therefore, improvements are needed in the formulation, mixing techniques, and curing time to produce soap of a safer quality that meets standards.

3. **Density Test**

Table 11. Density Test Result

Class	Description
LAT 1	Satisfactory
LAT 2	Satisfactory

Density testing was conducted by observing the hardness of the resulting soap. Based on the results in Table 11, the soaps from LAT 1 and LAT 2 fall into the "adequate" category. This indicates that the soap has formed, but its hardness is not yet optimal. This condition indicates that the saponification process has taken place but has not yet fully produced a dense and stable soap structure. The more optimal the saponification reaction, the higher the density and hardness of the resulting soap.

4. **Foam Test**

Table 12. Foam Test Result

Class	Foam Difference (cm)	Description
LAT 1	7,0 → 6,9 cm	Stable
LAT 2	4,0 → 3,5 cm	Stable

Foam stability testing was conducted by measuring the initial height and the change in height of the formed foam. The results showed that LAT 1 decreased from 7.0 cm to 6.9 cm, while LAT 2 decreased from 4.0 cm to 3.5 cm. Based on the evaluation criteria, both groups fall into the stable category because they have a foam difference of less than 1.0 cm. However, LAT 1 demonstrated better foam stability than LAT 2 because it experienced a smaller decrease. Theoretically, foam forms due to the presence of surfactant compounds that reduce the surface tension of water, thereby producing stable bubbles. Foam stability is influenced by the composition of the ingredients as well as the success of the saponification process, where an optimally formed soap structure will produce more stable foam.

Table 13. Test Results for the Quality of Class X LAT Bar Soap

Class	pH	Residual Alkali	Density	Foam
LAT 1	2	1	2	3
LAT 2	1	1	2	3

Based on Table 10, the quality of the bar soap produced by LAT 1 and LAT 2 shows no significant differences. LAT 1 achieved better results for the pH parameter, while for the residual alkali, density, and foaming capacity parameters, both groups showed similar results. Overall, the quality of the soap products obtained from LAT 1 and LAT 2 was relatively similar, with only slight differences observed in several testing parameters.

The variation observed in the pH values may be related to differences in ingredient measurement and mixing during the soap-making process. In contrast, similar results for residual alkali, density, and foam stability indicate that most groups followed comparable procedures throughout the project. Even so, small variations in laboratory practices and the accuracy of each production step may have contributed to the differences found between the products.

Examples of the solid soap products produced by each group are presented in Figure 1.

(a) (b)

Figure 1. Solid Soap Products Made from Papaya Extract (a) LAT 1 Class, (b) LAT 2 Class

The learning activities carried out through Project-Based Learning (PjBL) integrated with edu-ecopreneurship were documented throughout the project. Selected documentation of these activities is presented in Figure 2.

Figure 2. Documentation of Project-Based Learning (PBL) in the Production of Solid Soap

Figure 2 illustrates several stages of the soap-making project carried out by students, including material preparation, soap production, product testing, and presentation of results. The documentation shows that students were actively involved throughout the project. This observation is consistent with the practical skills assessment, which indicated high performance in preparing tools and materials, following laboratory procedures, and applying occupational safety practices during the activities.

Through their participation in the project, students engaged directly in the process of producing and evaluating solid soap from used cooking oil. The learning activities required students to perform measurements, conduct observations, record experimental data, and evaluate product quality based on the test results obtained. These activities provided opportunities for students to apply laboratory procedures while working collaboratively within their groups.

The project also incorporated elements of edu-ecopreneurship through the utilization of used cooking oil as a raw material for soap production. During the activities, students learned about the saponification process and observed how household waste could be converted into a useful product. In addition, discussions regarding product utilization and value introduced students to the potential economic benefits of waste-based products. Meanwhile, from an entrepreneurship perspective, students are introduced to the potential for developing bar soap as a product of both practical and commercial value, including opportunities for innovation in formulation, packaging, and product design.

The quality evaluation showed that several characteristics of the soap were still affected by the conditions of the saponification process. The high pH values and the detection of residual alkali suggest that the reaction between used cooking oil and NaOH may not have proceeded completely. These results may be associated with differences in ingredient measurement, mixing consistency, and process control during soap production.

Variations in product quality were also related to how the project activities were carried out by each group. Accurate weighing of materials, careful mixing, and adherence to laboratory procedures contributed to the characteristics of the soap obtained. As a result, the quality of the final product reflected both the production process and the practical performance demonstrated by students during the project.

Beyond producing a tangible product, the project provided opportunities for students to apply chemical concepts in a laboratory setting. Students were involved in planning activities, carrying out experimental procedures, evaluating product quality, and discussing the results obtained. These experiences allowed them to practice problem-solving, data interpretation, and decision-making throughout the project. The integration of educational, environmental, and entrepreneurial aspects into the learning process demonstrates that the implementation of PjBL based on edu-ecopreneurship is capable of providing a more comprehensive learning experience for students.

CONCLUSION

The implementation of Project-Based Learning (PjBL) integrated with edu-ecopreneurship through a project to make solid soap from used cooking oil with added papaya extract was successfully carried out by 10th-grade students in the class of Laboratory Analysis and Testing (LAT). This learning activity was able to develop students' practical skills to a level ranging from good to very good and produced solid soap of relatively similar quality in both classes. Although the density and foaming capacity parameters showed fairly good results, the pH value and free alkali content still require optimization of the saponification process. Overall, the implementation of PjBL integrated with edu-ecopreneurship supports the development of students' chemistry competencies, practical skills, environmental awareness, and entrepreneurial spirit.

ACKNOWLEDGMENTS

This research was carried out thanks to the facilities and opportunities provided by a vocational high school in Gresik, specifically the Laboratory Testing Analysis Program. Therefore, the author would like to thank the school for the support provided throughout the study. Gratitude is also extended to the supervising teachers and subject instructors for their guidance and mentorship. Additionally, the author would like to thank the field supervisor for their support and guidance throughout the research process. Furthermore, the author would like to express gratitude to the 10th-grade LAT students for their active participation in the laboratory activities and data collection.

REFERENCES

1. Fauziyah, N., Rahman, A., and Putra, D. 2021. Pengelolaan Limbah Minyak Jelantah Rumah Tangga sebagai Upaya Pengendalian Pencemaran Lingkungan. *Jurnal Pengabdian Lingkungan*, Vol. 5, No. 2, pp. 45–52.
2. Wahyuni, S., Lestari, D., and Prasetyo, H. 2022. Dampak Pembuangan Minyak Jelantah Terhadap Kualitas Air dan Tanah. *Jurnal Ilmu Lingkungan*, Vol. 20, No. 1, pp. 101–108.
3. Pratama, R., and Lestari, S. 2023. Analisis Senyawa Hasil Degradasi Minyak Goreng Bekas Terhadap Kesehatan. *Jurnal Kimia Terapan Indonesia*, Vol. 25, No. 1, pp. 12–18.
4. Utami, R., Nugroho, A., and Wibowo, E. 2022. Pembuatan Sabun Padat Berbasis Minyak Jelantah Sebagai Produk Ramah Lingkungan. *Jurnal Teknologi Kimia*, Vol. 11, No. 2, pp. 55–61.
5. Lubis, S. A. P., Syahputri, A., Sahara, R., Siregar, R. R., and Dermawan, D. A. 2025. Pemanfaatan Minyak Jelantah sebagai Bahan Dasar Pembuatan Sabun Ramah Lingkungan dengan Penambahan Essential Oil di Desa Pasar Rawa. *Kolaborasi: Jurnal Hasil*

Kegiatan Kolaborasi Pengabdian Masyarakat, Vol. 3, No. 4, pp. 82-91.

6. Nugroho, A., Putri, R., and Santoso, B. 2024. Penerapan Ekonomi Sirkular dalam Pengolahan Limbah Rumah Tangga. *Jurnal Lingkungan Berkelanjutan*, Vol. 6, No. 1, pp. 1–9.

7. Syah, A., Dianita, P. S., and Agusta, H. F. 2022. Efektivitas Tanaman Pepaya (Carica papaya L.) terhadap Penyembuhan Lika: A Narrative Review. *Jurnal Farmagazine*, Vol. 9, No. 1, pp. 1–9.

8. Nizar Zein, F. R. 2024. Implementasi Pembelajaran Berbasis Proyek (Project-Based Learning) di Sekolah Menengah Kejuruan (SMK) untuk Meningkatkan Keaktifan dan Fokus Siswa. *Jurnal Pembelajaran, Bimbingan, dan Pengelolaan Pendidikan*, Vol. 4, No. 5, pp. 19–27.

9. Fitri, H. M., Khaerunnisa, P., Setiawan, E., and Wardoyo, S. 2025. Peningkatan Keterampilan Pra-Vokasional Siswa SMK melalui Project-Based Learning (PjBL): Studi Literatur. *Jurnal Pendidikan Dan Pembelajaran Indonesia (JPPI)*, Vol. 5, No. 1, pp. 307–318.

10. Amalda, J., Karwur, H. M., and Ramadhan, M. I. 2023. Penerapan Model Pembelajaran Project Based Learning untuk Meningkatkan Hasil Belajar Siswa pada Mata Pelajaran Geografi. *GEOGRAPHIA : Jurnal Pendidikan Dan Penelitian Geografi*, Vol. 4, No. 1, pp. 23–31.

11. Ahmad, S.T., Watrianthos, R., Samala, A. D., Muskhir, M., and Dogara, G., 2023. Project-Based Learning in Vocational Education: A Bibliometric Approach. *International Journal of Modern Education and Computer Science*, Vol. 15, No. 4, pp.43–56.

12. Shrestha, N., and Rijal, M., 2022. Ecopreneurship: A Sustainable Model as Entrepreneurship Education for Transformation. *Journal of Kathmandu BernHardt College*, Vol. 4, No. 1, pp. 37–42.

13. Silvia, D., Munzil, and Yahmin, 2025. A Phenomenology of Project Based Learning in Vocational Analytical Chemistry Education. *Jurnal Inovasi Pembelajaran Kimia*, Vol. 7, No. 2, pp. 309–318.

14. Abera, B. H., Diro, A., and Beyene, T. T., 2023. The Synergistic Effect of Waste Cooking Oil and Endod (Phytolacca Dodecandra) on The Production of High-Grade Laundry Soap. *Heliyon*, Vol. 9, No. 6, e16889.