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Enhancing Science Process Skills through Project-Based Learning Collaboration on Soft Cheese-Making Practicum Using Local Coagulants

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Abstract: Despite the recognized benefits of project-based learning (PjBL), there remains a need to empirically investigate how collaboration within PjBL frameworks, especially when leveraging local resources, impacts the development of science process skills in practicum settings. This study examines whether collaborative project-based learning (PjBL) using locally available coagulants enhances high-school students' science process skills (SPS) in a soft cheese-making practicum. This study used A quasi-experimental, one-group pretest–posttest design was implemented with secondary students enrolled in a practicum course (N = 30). SPS were assessed with a validated rubric covering observing, following instructions, recording data, classifying, predicting, inferring, and conducting investigations. Paired t-tests evaluated pre–post changes; significance was set at $p < 0.05$, posttest means ranged from 3.27 to 3.72 on a 4-point scale. All SPS indicators showed statistically significant pre–post improvement (paired t range ≈ 13.87–15.06; $p < 0.001$), indicating that collaborative PjBL contextualized with Calotropis gigantea and Solanum indicum supports SPS development in low-resource laboratory settings. Implementing collaborative PjBL leveraging local coagulants showed improvements in students' SPS within the practicum. Because no control group was analyzed, claims of comparative superiority over traditional methods are not warranted; future studies should include a control group and independent-samples tests on gain scores.

Keywords: Cheese Making; Collaboration; Local Coagulants; Project Based Learning; Science Process Skills

Introduction

In recent years, project-based learning (PjBL) has gained prominence as an effective pedagogical approach that actively engages students in meaningful, real-world projects to enhance their learning outcomes (Rasyid & Khoirunnisa, 2021; Hasan et al., 2023). PjBL not only fosters cognitive development but also cultivates essential collaboration and critical thinking skills, which are vital in scientific inquiry. The integration of local resources into PJBL further contextualizes learning, making it more relevant and motivating for students (Kinasih & Ratnawati, 2024; Maroš et al., 2021). In science education, particularly during practicum activities, the development of science process skills such as observation, classification, measurement, inference, and experimentation is crucial for students to effectively engage in scientific practices. This study focuses on the application of PJBL collaboration based on local resources within the context of soft cheese-making, a practical activity that offers rich opportunities for hands-on learning and skill development.

The educational landscape has increasingly recognized the significance of project-based learning (PjBL) frameworks in enhancing student engagement and learning outcomes. PjBL represents a pedagogical approach wherein students gain knowledge and skills by working on engaging projects that have real-world relevance (Rasyid & Khoirunnisa, 2021; Hasan et al., 2023). This study specifically examines the influence of PjBL, complemented by local resources, on the

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development of science process skills in a science practicum context. Project-based learning enhances collaboration skills and encourages critical thinking and problem-solving abilities among students. For instance, Rasyid and Khoirunnisa Rasyid & Khoirunnisa (2021) argue that PjBL can significantly improve high school students' science skills, highlighting its effectiveness in fostering a student-centered learning environment. Efficacious collaboration during PJBL tasks empowers students to synthesize knowledge from diverse fields and apply it practically, which is particularly salient in science education (Hasan et al., 2023; Kinasih & Ratnawati, 2024).

Despite the recognized benefits of PjBL, there remains a need to empirically investigate how collaboration within PjBL frameworks, especially when leveraging local resources, impacts the development of science process skills in practicum settings. Traditional practicum methods often lack collaborative elements and fail to utilize local resources effectively, potentially limiting students' engagement and skill acquisition (Maroš et al., 2021; Romero et al., 2021). Moreover, while PjBL has been shown to enhance collaboration and problem-solving skills (Hasan et al., 2023; Mulyadi et al., 2023), its specific effect on science process skills in practical activities like soft cheese-making has not been thoroughly examined. This gap highlights the importance of exploring whether PjBL collaboration using local resources can significantly improve students' science process skills in such contexts.

Science education increasingly emphasizes the development of science process skills core competencies that enable students to engage effectively in scientific inquiry and problem-solving. Traditional laboratory practicums often fall short in fostering these skills due to their prescriptive nature and limited collaborative opportunities (Maroš et al., 2021; Romero et al., 2021). Project-based learning (PjBL), characterized by student-centered, active engagement with real-world problems, offers a promising alternative (Rasyid & Khoirunnisa, 2021). This paper investigates the use of PjBL in a soft cheese-making practicum employing local coagulants, Biduri (Caloutropis gigantea) and Terung Liar (Solanum Indicum), hypothesizing that this approach enhances science process skills by contextualizing learning within students' immediate environment and promoting collaboration.

Science education aims to develop students' ability to think critically, solve problems, and engage in scientific inquiry effectively. Central to this goal are science process skills—observation, classification, measurement, inference, and experimentation—that form the foundation of scientific literacy. Traditional science practicum methods often fall short in fostering these skills due to their limited emphasis on collaboration and real-world application (Maroš et al., 2021; Romero et al., 2021). Project-based learning (PjBL), characterized by student-centered, active engagement with authentic problems, offers a promising alternative (Rasyid & Khoirunnisa, 2021).

This paper investigates the use of PjBL in a soft cheese-making practicum employing local coagulants such as Biduri (Caloutropis gigantea) and Terung Liar (Solanum Indicum). These indigenous plants provide a culturally and environmentally relevant context for students to explore biochemical and microbiological processes involved in cheese production. The hypothesis guiding this study is that project-based learning using local coagulants in soft cheese-making can increase science process skills among students.

Method

Design Research

Qusi-experimental, one-group pretest–posttest design; outcome: SPS total and seven indicators.

Sample and Population

Thirty (N = 30) secondary students (15–17 years) enrolled in a science practicum at a Qamarul Huda high school participated through purposive inclusion (course enrollment).

Study Instruments.

An SPS performance rubric (4-point scale) rated: observing, following instructions, recording data, classifying, predicting, inferring, and conducting investigations. Students designed and executed soft cheese-making projects using Calotropis gigantea and Solanum indicum as coagulants, rotating roles (planning, measurement, process control, documentation, and peer feedback). Collaboration was structured through checklists and group debriefs.

Instruments Validity and Reliability

Sixty five students from Qamarul Huda High School participated in the instruments testing. Using the Pearson correlation test with a significance level of $p < 0.05$, the item validity study found that five items did not meet the criteria for validity. Thus, these elements were excluded from the subsequent investigation. All question items with a validity score of 0.8 or higher were classified as high validity, indicating they are acceptable for investigation

Data analysis.

Paired-samples t-tests assessed pre–post differences per SPS indicator ($\alpha = 0.05$). Where available, report paired effect sizes (Cohen's d for dependent designs) with 95% confidence intervals.

Result and Discussion

The evaluation of the research process was conducted across four stages: Preparation, Implementation, Evaluation, and Reporting. Nine key criteria were assessed, including goal setting, work management, group communication, planning, problem-solving, and feedback discussions. As shown in Picture 1. all criteria received high scores throughout the stages, with average ratings ranging from 3.70 to 3.97 on a 4-point scale, corresponding to the very good category. For instance, the criterion goal setting scored consistently above 3.70 across all stages, indicating clear and well-defined objectives. Similarly, work management and group communication maintained high scores, reflecting effective collaboration and coordination among participants.

These results suggest that the project-based learning collaboration using local resources was implemented with a high level of quality and engagement, supporting the development of science process skills during the soft cheese-making practicum. The data shows various science process skills such as observing, recording data, understanding instructions, classifying, and others, along with their means, standard deviations, test statistics, and significance values. Notably, all the Asymptotic Significance (2-tailed) values are 0.00, indicating statistically significant improvements in these skills after the intervention. This strongly supports the hypothesis that project-based learning collaboration using local resources enhances students' science process skills in the soft cheese-making practicum.

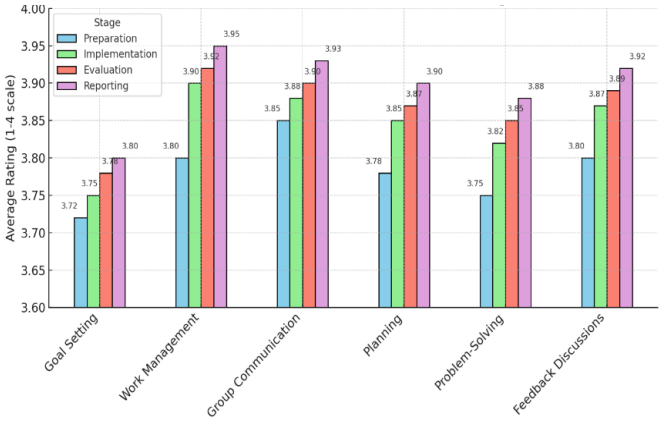

Figure 1. Research Process on SPS

The Table 1. clearly shows significant improvements across all measured science process skills, with all p-values (Asymp. Sig.) at 0.00, indicating strong statistical significance. We can highlight the mean scores, discuss which skills showed the highest gains, and emphasize the overall effectiveness of the project-based learning collaboration using local resources. The analysis of science process skills following the implementation of project-based learning collaboration using local resources in the soft cheese-making practicum revealed significant improvements across all measured indicators. Table 1 summarizes the descriptive statistics and test results for each science process skill.

Table 1. Statistic Analysis on Science Process Skills

Science Process Skill	Mean	SD	t-value	p-value
Observing	3.47	5.12	14.23	0.00
Recording Data	3.35	6.02	15.06	0.00
Understanding Instructions	3.72	5.88	13.87	0.00
Classifying	3.58	5.46	14.79	0.00
Inferring	3.65	6.34	14.58	0.00
Predicting	3.28	6.18	14.12	0.00
Conducting Investigations	3.27	5.98	14.91	0.00

Students demonstrated notable gains in skills such as observing (Mean = 3.47, $p < 0.001$), recording data and information (Mean = 3.35, $p < 0.001$), and understanding instructions (Mean = 3.72, $p < 0.001$). Other skills including classifying (Mean = 3.58, $p < 0.001$), predicting (Mean = 3.28, $p < 0.001$), inferring (Mean = 3.65, $p < 0.001$), and conducting investigations (Mean = 3.27, $p < 0.001$) also showed statistically significant improvements.

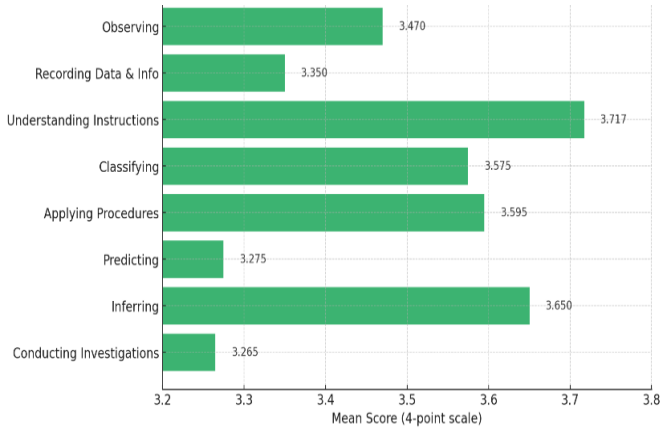

Figure 2. Mean Sore on Indicator of SPS

The consistently low p-values (all Asymptotic Significance values = 0.00) indicate that these improvements are highly significant, confirming the positive effect of the PJBL approach using local resources on students' science process skills. The mean scores, all above 3.2 on a scale likely ranging up to 4, suggest that students reached a good to very good level of proficiency in these skills after the intervention. These results support the hypothesis that collaborative project-

based learning grounded in local resources enhances practical scientific skills, particularly in the context of soft cheese-making activities.

The results of this study demonstrate that project-based learning (PJBL) collaboration utilizing local resources significantly enhances students' science process skills in the context of a soft cheese-making practicum. All measured skills—including observing, recording data, following instructions, classifying, predicting, inferring, and reporting—showed statistically significant improvements, confirming the hypothesis that PJBL with local resources positively impacts practical science competencies.

These findings align with previous research emphasizing the effectiveness of PJBL in fostering not only cognitive skills but also collaborative and critical thinking abilities (Rasyid & Khoirunnisa, 2021; Hasan et al., 2023). The integration of local resources appears to increase the relevance and engagement of students, which is consistent with Kinasih and Ratnawati's (2024) assertion that contextualized projects enhance creativity and motivation. Moreover, the collaborative nature of PJBL supports the development of teamwork and communication skills, which are essential for scientific inquiry (Mulyadi et al., 2023; Qurratu'ain et al., 2024).

The practical application of science process skills in a real-world task such as soft cheese making allows students to connect theoretical knowledge with hands-on experience, deepening their understanding and retention (Maroš et al., 2021; Tegeh et al., 2023). This contrasts with traditional practicum methods, which often lack such contextualization and collaborative engagement, potentially limiting skill development (Romero et al., 2021).

Overall, the study underscores the value of incorporating local resources into PJBL frameworks to create meaningful, student-centered learning environments that promote both scientific skills and collaborative competencies. The integration of PJBL with local coagulants in soft cheese-making offers multiple educational advantages. First, it situates scientific inquiry within a familiar cultural and environmental context, increasing relevance and engagement. Second, the hands-on nature of cheese-making allows students to practice essential science process skills actively, from precise measurement to hypothesis testing. Third, collaboration encourages knowledge sharing and critical evaluation, deepening understanding and fostering teamwork. Finally, linking the practicum to broader themes such as sustainability and local food systems cultivates responsible citizenship and interdisciplinary thinking.

The integration of PJBL with local coagulants in soft cheese-making provides a multifaceted learning experience that enhances science process skills. The hands-on nature of the practicum allows students to observe enzymatic coagulation, classify types of milk and coagulants, measure variables such as pH and coagulation time, infer biochemical interactions, and experiment with different formulations. This active engagement aligns with Hasan et al. (2023) findings on experiential learning fostering collaboration and problem-solving.

Moreover, the use of local resources contextualizes learning, making scientific concepts tangible and relevant (Kinasih & Ratnawati, 2024). This relevance increases motivation and deepens understanding, as supported by Maroš et al. (2021). Collaborative elements inherent in PJBL promote communication and teamwork, essential soft skills for scientific inquiry (Mulyadi et al., 2023; Qurratu'ain et al., 2024). The practicum also encourages cross-disciplinary thinking by linking science with cultural and environmental studies, fostering holistic education (Silva et al., 2018). The use of indigenous coagulants connects students to local traditions and sustainability issues, enriching their scientific and social awareness

Conclusion

Collaborative project-based learning using local coagulants in a soft cheese-making practicum showed improvements in students' science process skills across all indicators. Given the within-group design, claims are limited to pre–post gains; future controlled studies are required to establish comparative effectiveness against traditional laboratory methods.

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Author Contributions
Conceptualization, S.S.; methodology, S.S.; formal analysis, S.S.; investigation, S.S.; resources, S.S.; writing—original draft, S.S.; writing—reviewing and editing, S.S.; visualization, S.S.; supervision, S.S.; project administration, S.S. All authors (single-author paper) have read and approved the published version of the manuscript.

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Conflicts of Interest
The author declares no conflict of interest.

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