Katalis: Jurnal Penelitian Kimia dan Pendidikan Kimia e-ISSN: 2721-9038
Vol. 8, No. 1, Tahun 2025 p-ISSN: 2721-902X
https://ejurnalunsam.id/index.php/katalis/

THE IMPLEMENTATION OF PROJECT-BASED WORKSHEETS TO DEVELOP STUDENTS' SCIENTIFIC PERFORMANCE THROUGH EDIBLE FILM PRODUCTION

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Abstrak

Rendahnya kinerja ilmiah siswa dalam pembelajaran kimia menjadi salah satu permasalahan utama dalam pendidikan, terutama karena pendekatan pembelajaran yang masih didominasi oleh metode konvensional dan berpusat pada guru. Pembelajaran yang kurang melibatkan siswa secara aktif dapat menghambat pengembangan keterampilan berpikir kritis, pemecahan masalah, dan kemampuan kinerja ilmiah siswa. Penelitian ini bertujuan untuk mengembangkan kinerja ilmiah siswa melalui penerapan Lembar Kerja berbasis proyek dalam pembuatan edible film dari limbah biji nangka (Artocarpus heterophyllus). Penelitian menggunakan pendekatan kuantitatif melalui penerapan metode pre-experimental dengan desain one-shot case study yang melibatkan 34 siswa kelas XI jurusan Kimia Industri di salah satu Sekolah Menengah Kejuruan (SMK) di Kota Cimahi. Instrumen penelitian terdiri dari lembar observasi aktivitas siswa, lembar kerja berbasis proyek, dan lembar penilaian kinerja ilmiah. Hasil menunjukkan bahwa aktivitas siswa selama pembelajaran memperoleh nilai rata-rata 97, pengerjaan lembar kerja mencapai nilai rata-rata 94, dan kierja ilmiah siswa sebesar 92, masing-masing terkategori sangat baik. Temuan ini membuktikan bahwa penggunaan lembar kerja berbasis proyek mampu mengembangkan keaktifan, kemandirian, dan kemampuan ilmiah siswa, serta menjadi alternatif solusi terhadap permasalahan pembelajaran sains yang masih pasif di sekolah.

Kata Kunci: Lembar Kerja Berbasis Proyek, Kinerja Ilmiah, Edible Film, Limbah Biji Nangka

Abstract

The low scientific performance of students in learning chemistry is one of the main problems in education, mainly because the learning approach is still dominated by conventional methods and teacher-centered. Learning that does not actively involve students can hinder the development of critical thinking skills, problem solving, and students' scientific performance abilities. This study aims to develop students' scientific performance through the application of project-based worksheets in making edible film from jackfruit seed waste (Artocarpus heterophyllus). The research used a quantitative approach through the application of pre-experimental methods with a one-shot case study design involving 34 students of class XI majoring in Industrial Chemistry at one of the vocational high schools (SMK) in Cimahi City. The research instruments consisted of student activity observation sheets, project-based worksheets, and scientific performance assessment sheets. The results showed that student activity during learning obtained an average score of 97, worksheet work achieved an average score of 94, and student scientific performance of 92, each categorized as very good. These findings prove that the use of project-based worksheets can develop students' activeness, independence, and scientific abilities, and become an alternative solution to the problem of passive science learning in schools.

Keywords: *Project Based Worksheet, Scientific Performance, Edible Film, Jackfruit Seed Waste*

e-ISSN: 2721-9038
p-ISSN: 2721-902X

INTRODUCTION

Waste management is essential due to its adverse impacts on the environment and human health. Poorly managed waste can contaminate water, soil, and air. Proper waste management involves preventing waste generation from the outset and enhancing opportunities for reuse through environmentally friendly processes to support environmental sustainability and human well-being (Huemer & Flygansvær, 2025). The Reuse, Reduce, Recycle (3R) method serves as an alternative strategy for minimizing waste. Through recycling, waste can be converted into various other useful materials such as organic fertilizer, animal feed, biogas, and others (Andriani et al., 2021).

An appropriate learning strategy in schools is crucial for raising awareness about waste management. Students not only need to understand the theoretical aspects of issues such as environmental problems, but also need to engage with real-world challenges through meaningful learning activities. In the 21st century, this has become increasingly important and significantly influences human life, including the use of media in education and learning methods (Sunarya et al., 2024). Therefore, learning should be designed using models and teaching materials that support 21st-century skills, so that students are prepared to actively and responsibly face global challenges (Pramasdyahsari et al., 2023).

One type of educational media that supports active learning, enhances student participation, and encourages quick responses is the worksheet (Gyanwali, 2018). The use of worksheets has become increasingly important in chemistry education, which is often perceived as complex and uninteresting when presented solely through theoretical approaches (Junaidi et al., 2017). To address this issue, an alternative learning approach that directly involves students is project-based learning (Chu et al., 2023). Project-based learning helps students explore new ideas, improve critical thinking skills, enhance collaboration, and develop time management abilities (Burnham, 2020). Moreover, it provides students with new experiences that can enrich their learning and foster creativity in problem-solving and product development (Gultom & Muchtar, 2022). In this context, worksheets can serve as tools to support project-based learning, specifically in the form of project-based worksheets. This is because project-based learning emphasizes active student involvement in enhancing understanding by independently identifying and solving problems through projects (Diawati et al., 2018).

Science learning is often passive, resulting in low levels of students' scientific performance skills (Hutasoit, 2021). In fact, students must possess scientific performance skills as an essential part of education, particularly in the field of science. In this regard, project-based learning is an appropriate approach, as it not only provides students with professional knowledge but also guides them in independently developing their own projects (Chen et al., 2022). Active participation and student engagement in the learning process can enhance success in scientific performance. Consequently, many modern laboratory methods aim to teach students not only theoretical knowledge but also scientific thinking and practical skills (Reynders et al., 2019). Active learning encourages student involvement through questioning, exploration, and reflection. When presented in an engaging manner, this principle can help students achieve relevant and contextual science learning objectives (Scalise et al., 2025).

One of the most concerning issues in Indonesia is conventional plastic waste. Derived from non-renewable materials, this type of waste is difficult to decompose and poses risks to human health, nature, and the future of the Earth (Mirkarimi et al., 2022). According to data from the National Waste Management Information System (SIPSN), the total waste generated from human activities in Indonesia reaches 31 million tons per year. Among this, plastic waste accounts

e-ISSN: 2721-9038
p-ISSN: 2721-902X

for 19.1%, which is approximately 5.92 million tons per year (Fatih et al., 2024). To address this issue, the use of edible films serves as a solution and an alternative to conventional plastic, as they are lightweight, shatter-resistant, transparent, easily labeled, and cost-effective (Syarifuddin et al., 2025). This is because recycling techniques can effectively help reduce plastic waste and the use of single-use plastics, thereby decreasing global plastic pollution (Song & Park, 2024).

Therefore, to achieve sustainable solutions, the use of renewable raw materials is essential. Jackfruit seeds, which contain a high starch content of 86.7% per 100 grams, can be utilized as an alternative in the production of edible films (Kalse & Swami, 2022). Additionally, jackfruit seeds contain a high amylose content of 32.14%. Starch with a high amylose level can produce edible films that are both flexible and strong (Le et al., 2023). Starch is one of the natural polymers with great potential for use as a base material in edible film production due to its environmentally friendly properties (Ghoshal & Kaur, 2023). Previous research has shown that biodegradable plastic derived from jackfruit seed starch possesses a tensile strength of 21.57 MPa and an elongation of 6.58%, and is capable of degrading within two weeks (Nuryati et al., 2019). Despite its significant potential as an abundant local starch source, there has been limited research on the use of jackfruit seeds (Artocarpus heterophyllus) as raw material for edible film production. Moreover, no studies have yet reported the implementation of project-based learning involving the utilization of jackfruit seeds for edible film development.

Therefore, this study reports the implementation of project-based worksheets in utilizing jackfruit seeds as raw material for producing edible film, aimed at developing students' scientific performance.

RESEARCH METHODS

This study employed a quantitative approach. The independent variable in this research is the project-based worksheet, while the dependent variable is students' scientific performance. The method used is a pre-experimental design with a one-shot case study. The treatment was administered through project-based worksheets, followed by observations and drawing conclusions from the observed results. There was no control group in this study; therefore, the effect of the treatment on the variable could be directly observed (Hardiyanti & Herda, 2023). The study was conducted in Grade XI of the Industrial Chemistry major at a Vocational High School (SMK) in Cimahi City, consisting of 34 students. This school was selected because its educational policies were considered supportive of the research process.

The instruments used include: (1) an observation sheet for collecting data on student activities during the learning process; (2) a project-based worksheet as a learning medium, which provides data on students' ability to complete the project-based tasks; and (3) a scientific performance assessment sheet as a measurement tool to evaluate students' abilities in conducting practical activities and using tools and materials. The collected data were then analyzed using the following formula.

$$\text{Score} = \frac{\text{Obtained score}}{\text{Maximum score}} \times 100$$

This study was conducted in three stages: (1) Preparation stage, in which the researcher reviewed the phase F learning outcomes for grade XI, conducted a literature review to determine the research title, formulated the research problem, objectives, design, and instruments. Subsequently, the instruments were validated by experts until deemed suitable for research; (2) Implementation stage, where the project-based worksheet was applied using the validated instruments; and (3) Final stage, which involved processing the data collected during the research and drawing conclusions based on the findings.

RESULTS AND DISCUSSION

e-ISSN: 2721-9038
p-ISSN: 2721-902X

Research on the implementation of project-based learning in the production of edible films from jackfruit seeds (Artocarpus heterophyllus) to develop students' scientific performance was conducted at a vocational high school (SMK) in Cimahi in the chemistry subject. This study involved 34 students from class XI-KI-A, who were divided into six groups, each consisting of five to six students.

Instrument Validation

The instruments used in this study were validated by experts in subject matter and education prior to implementation. The purpose of the validation was to ensure that each component of the instrument accurately reflects the intended construct being measured, in alignment with the measurement objectives (Nabil et al., 2022). The validation sheet covered three assessment aspects: presentation, content, and language. Each component was evaluated using a 4-point Likert scale. A score of 4 on this scale indicates a very high level of appropriateness, while a score of 1 indicates a lack of appropriateness.

Based on the results of instrument validation by three expert validators in subject matter and education, the research instrument was classified as highly feasible for use. With feasibility percentages of 87%, 95%, and 100%, each validator confirmed that the instrument met the criteria of content, construction, and technical aspects appropriately. Validator 3 gave the highest score, indicating that the instrument was considered fully appropriate without requiring revisions. Meanwhile, the scores from Validators 1 and 2, although below 100%, still indicated a high level of feasibility, with only minor revisions suggested. One of the suggested revisions concerned the use of language, which was deemed insufficiently standardized.

Student Activity Observation Sheet

The observation sheet is assessed by an observer through direct observation during the learning process in each group. The observer's monitoring covers student activities throughout all learning stages, beginning with the introduction, followed by the core activities involving project-based learning steps, and concluding with the closing phase.

The results of the analysis of student activities based on the observation sheet can be seen in Table 1.

Table 1. Results of Student Activity Observation

No	Project-Based Learning Stages	Average Score	Interpretation
1	Problem analysis	94	Very good
2	Project design planning	90	Very good
3	Conducting research	100	Very good
4	Drafting/prototyping product	100	Very good
5	Measuring, evaluating, and improving product	100	Very good
6	Finalizing and publishing product	98	Very good
Overall Score		**97**	**Very good**

Based on Table 1, the analysis of the observation sheets yielded average scores across all aspects of the observed learning stages. The overall average student activity score was 97, which falls into the very good category. These results indicate that student activity during classroom learning was very good and reflects active participation as well as student enthusiasm throughout the entire learning process. Each aspect of student activity showed strengths. In the sections involving conducting research, creating product drafts/prototypes, and making improvements, the highest average score was 100. Meanwhile, the project design planning section received the lowest average score of 90. This is consistent with previous research showing that the implementation of project-

e-ISSN: 2721-9038
p-ISSN: 2721-902X

based learning models increases students' active involvement in the teaching process, thereby resulting in improved cognitive achievement (Anggriana & Muhardi, 2017). Student activities during learning are illustrated in Figure 1.

Figure 1. Students Activities During the Apperception Phase

Project-Based Worksheets

Project-based worksheets are activity sheets used by students to complete project tasks (Nelson & Tarigan, 2022). These worksheets include complex assignments based on questions and problems that require students to think critically, solve problems, make decisions, and analyze. Additionally, project-based worksheets provide opportunities for students to collaborate, thereby contributing to their collaborative skills. The main purpose of using project-based worksheets is to give students the freedom to complete their tasks, enabling them to actively participate in the learning process and develop independence in problem-solving (Kusumawardhani & Raharjo, 2019).

In the implementation of project-based worksheets, students are organized into six groups, each consisting of five to six members. The students then follow the stages of project-based learning using the worksheet media, which include: (1) analyzing the problem; (2) designing the project plan; (3) conducting research; (4) preparing a draft/prototype of the product; (5) measuring, evaluating, and refining the product; and (6) finalizing and publishing the product (Novalia et al., 2025).

At the problem analysis stage, the majority of students were able to identify relevant issues based on the worksheet context, particularly through the presented discourse. This is evident from how students reviewed and comprehended the discourse, which served as the basis for determining the focus of the problem. They were able to identify the main aspects of the discourse and then formulate them into clear, focused questions aligned with the objectives of the practical activity. The students' ability in problem analysis achieved an average score of 95. According to the predetermined assessment criteria, this score indicates a high level of achievement in the 'very good' category. Therefore, it can be concluded that students have a good understanding of how to analyze problems as a crucial component of the scientific process during practical work. This underscores the importance of problem analysis in project-based learning to enhance students' comprehension of scientific concepts and skills (Ainun et al., 2021).

In the subsequent stage of project design, group performance varied. Students were asked to design the experimental principles, identify tools and materials, and develop the experimental procedure. Some groups successfully constructed the procedure in a sequential and logical manner. These results are consistent with the statement that a well-defined project design and clear objectives are key to enhancing students' ability to work independently (Novalia et al., 2025). However, several groups still made minor errors, as indicated by unclear procedures and incomplete listings of tools and materials. This suggests that further guidance is needed during the design stage to ensure that each group can produce a well-organized project plan. At this stage, the average score obtained was 93, categorized as 'very good'.

In the research implementation phase, students actively participated in the activity of making edible films derived from jackfruit seed starch. Hands-on laboratory activities

e-ISSN: 2721-9038
p-ISSN: 2721-902X

that directly engage students are one of the effective ways to enhance the quality and benefits of practical work (Paterson, 2019). During the practicum, students were instructed to record and complete data based on their actions and observations. Most students were actively involved in data collection, carefully noted each observable change, and participated in group discussions. Students demonstrated the ability to apply scientific performance, which is an essential aspect of project-based learning. However, some groups did not fully complete certain tasks. For example, they submitted only one observation data point, despite being instructed to provide two. At this stage, the average score achieved was 84, categorized as 'very good'.

During the process of edible film production, gelatinization occurs, which is the transformation of starch structure induced by specific temperature and humidity conditions. Throughout this process, the native, rigid structure of starch is permanently altered into a softer and more elastic gel (Renzetti et al., 2021). The resulting product is presented in Figure 2.

Figure 2. Edible Film Products Made from Jackfruit Seed Waste

In the subsequent stage of drafting the product prototype, students were asked to analyze the process and outcome of the edible film production they had carried out, guided by a set of questions provided in the worksheet. These questions addressed aspects such as the effect of varying jackfruit seed starch mass on the color of the product, the role of glycerol, and the function of heating in the edible film production process. This practicum encouraged students to think critically, reflect on their results, consider any human errors that occurred during the experiment, and seek solutions to those errors (Hugerat, 2020). The results of this stage indicated that students were able to answer the questions appropriately and identify as well as discuss the imperfections they encountered during the practicum. Overall, most groups successfully completed this stage, achieving an average score of 91, categorized as 'very good'.

The next stage involves measuring, evaluating, and improving the product. This activity engages students in conducting organoleptic, swelling, and solubility tests on the edible film product. Throughout the process, students demonstrated strong discipline in carrying out each testing phase. This discipline emerged as a result of their direct involvement in the practical activities (Hasanah et al., 2024). Although most of the products produced were not yet fully optimal due to several factors, one group succeeded in producing a product of relatively good quality. The average score obtained was a perfect 100, categorized as 'very good'.

The final stage involved product finalization and publication. In this activity, students were asked to prepare a practical report in the form of a poster and present it in class. Students were able to communicate the practical results quite well during the presentation, including stating the objectives, observation data, discussion, and conclusions. In the discussion section, students explained the functions of heating, plasticizer, and the drying process. Film properties such as color, strength, and the ability to retain water or air are influenced by drying temperature, heating process, and plasticizer addition, as these affect the molecular arrangement in the edible film (Daza et al., 2018). They also explained the reasons why the produced products were not perfect. Additionally, students' creativity was evident, as demonstrated by the posters'

e-ISSN: 2721-9038
p-ISSN: 2721-902X

attractive, informative, and clearly structured appearance. The average score obtained was a perfect 100, categorized as 'very good'.

Based on the explanations of each stage presented in the worksheet, the overall data analysis results can be seen in Table 2.

Table 2. The Average Score of Student Worksheets

No	Project-Based Learning Stages	Average Score	Interpretation
1	Problem analysis	95	Very Good
2	Project design planning	93	Very Good
3	Conducting research	84	Very Good
4	Drafting/prototyping product	91	Very Good
5	Measuring, evaluating, and improving product	100	Very Good
6	Finalizing and publishing product	100	Very Good
Overall Score		**94**	**Very Good**

The overall average score in the worksheet phase was 94, categorized as very good. The lowest average score was obtained in the research phase, which was 84 and categorized as good. Meanwhile, the highest average scores were achieved in the product improvement and finalization phases, with a perfect score of 100, categorized as very good.

Scientific Performance

In project-based chemistry learning, students' scientific performance is crucial, especially in the context of practical work, which involves scientific thinking and actions. The measurement of scientific performance includes five main indicators: formulating problems, designing experiments, conducting experiments, collecting data, and communicating results (Sholehat & Rasmawan, 2016). The assessment focuses on directly involving students in the experiment to produce edible film from jackfruit seed starch. In this process, several steps must be carried out, including weighing the starch using an analytical balance, measuring distilled water, and continuing the edible film production process until the final product is formed.

In the aspect of weighing starch, most students demonstrated good scientific performance. This is evidenced by relatively high assessment scores across almost all criteria. One key indicator is accuracy in weighing the materials. Most students were able to weigh the starch according to the specified measurements, indicating their understanding of the procedures and ability to correctly use the analytical balance. Furthermore, students exhibited responsibility and discipline during the practical work by maintaining a clean workspace and cleaning the balance after use. Such responsibility and discipline reflect a high level of motivation to achieve (Eliyart & Rahayu, 2021).

Next is the aspect of measuring distilled water. At this stage, students demonstrated good scientific performance, particularly in placing the measuring cylinder on a flat surface and keeping it stable during measurement. They also measured the volume of distilled water accurately, indicating their understanding of how to correctly read the scale. The students' ability to measure distilled water using the lower meniscus boundary reflects their knowledge of properly measuring the volume of colorless liquids. This aligns with the statement that measurements of colorless solutions should consider the lower concave meniscus boundary (Sultanni et al., 2023).

Next, the aspect of edible film fabrication is considered. By performing each step systematically and according to the procedure, students demonstrated good scientific performance in producing edible films. They not only followed the instructions but also understood the theoretical processes, such as gelatinization and the role of glycerol. Glycerol, as a plasticizer, can enhance the strength of the edible film by penetrating the

e-ISSN: 2721-9038
p-ISSN: 2721-902X

polymer matrix and disrupting the intermolecular bonds of starch, thus facilitating the interaction between the plasticizer and starch (Wang et al., 2025). Students not only acquired technical skills but also took responsibility for maintaining a clean and organized laboratory, which reflects their accountability and active involvement in scientific practice.

Overall, students' scientific performance achievement based on project-based worksheets can be more clearly observed in Figure 3.

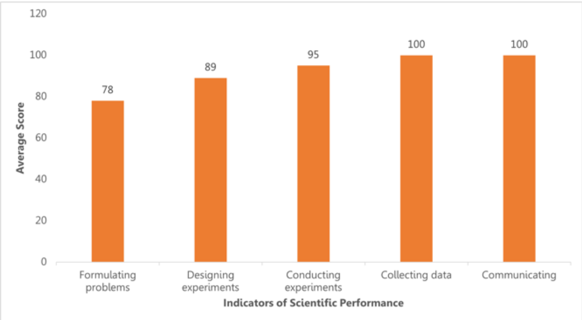

Figure 3. Average Student Scientific Performance Score

Based on the explanation above, the use of project-based worksheets plays a significant role in developing students' scientific performance. Active involvement in each stage of the learning process, as well as in the implementation of practical activities, serves as a relevant indicator for assessing the extent to which students' scientific performance has developed. This is consistent with previous research, which found that project-based learning can be used to enhance scientific performance, as it improves conceptual understanding of the subject matter and provides students with opportunities to actively participate in learning activities (Muntari et al., 2018).

CONCLUSION

Based on the research results, it was shown that students were directly involved in practical activities through a systematic process. The average overall student activity score was 97, categorized as very good. Project-based learning also enhanced students' scientific performance, with an overall average score of 92, categorized as very good. Project-based worksheets were effective in helping students become more active, independent, and focused during learning.

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